RISK ANALYSIS OF SMALLHOLDER FARMERS IN CENTRAL AND NORTH-EAST THAILAND

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Satit Aditto

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Agriculture contributes approximately nine per cent to both of Thailand's GDP and exports. Thai farmers are basically smallholders and large numbers of them live in rural areas and below the poverty line. Pervasive and complicating risks cause a farmer's income to fluctuate every year. The Thai government has tried to strengthen and enhance farmers' ability to cope with risk and stabilize their farm income. These issues have been widely discussed in the 10th National Economic and Social Development Plan (2007-2011). The development of appropriate solutions to deal with risks has been impeded due to the lack of empirical studies on farmers' responses to risk and the impacts of risk at the farm level in Thailand.

This study investigates the farmers' perceptions of risk and risk management strategies and examines whether the farmers' characteristics can be influenced by those perceptions. The farmers' risk aversion is also elicited using the equally likely certainty equivalent approach and four different utility functions are employed to analyse their performances in terms of risk preference classification. Stochastic efficiency with respect to a function (SERF) is applied to determine the risk efficient farming systems for the farmers in central and north-east regions of Thailand. The data for this study were obtained from a face-to-face survey of central and north-east region farmers together with the historical data of prices and yields at the provincial level (1998-2008) from the Office of Agricultural Economics for each individual crop and livestock in the study areas.

The results indicate that marketing risks associated with the unexpected variability of input and product prices are considered as important sources of risk among the farmers in both regions. The production strategy related to the purchase of farm machinery to replace labour is perceived as an important strategy to manage risk by the central region farmers, whereas the north-east region farmers considered storing feed and/or seed reserves as an important strategy. The results also show that some farm and farmers' characteristics (e.g. *gender*, *education*, *off-farm work*, *farm size* and *farm location*) significantly impact the risk perceptions of the farmers in both regions. The negative exponential utility function is performed to describe the farmers' risk behaviour. This functional form classified all sampled farmers in both regions as risk averse.

The SERF results show that maize followed by sorghum (CRFP4) is the most risk efficient farming system for the extremely risk averse rain-fed farmers in the central region. Intensive planting of wet rice and dry rice cultivation (CIFP1) is preferred by the extremely risk averse central region irrigated farmers. In addition, wet rice and cassava with raising small herd of cattle (NRFP5) is the most economically viable farming system for the extremely risk averse rain-fed farmers in the north-east region, while two rice crops with raising cattle (NIFP3) is preferred by the extremely risk averse north-east irrigated farmers.

Keywords: risk, stochastic efficiency, farm, uncertainty, Thailand

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Chapter 1
Introduction

1.1 Introduction

Risk is one of the most important factors that affect a person's welfare and it is commonly associated with the probability of unexpected loss or injury (Dallas, 2006; Harwood, Heifner, Coble, Perry, & Somwaru, 1999). Conversely, risk is widely viewed as a complicated factor that influences decision making under uncertain conditions that may affect outcomes in the future (Hardaker, Huirne, Anderson, & Lien, 2004; McCarl & Spreen, 1996).

There are different definitions of risk and how it is determined. Levy (2006, p. 1) stated that *"people may have a feel as to what risk means, but if asked how to measure it, there would be a little consensus"*. Knight (1921) cited by Rose (2001) emphasized the sharp distinction between risk and uncertainty. Risk can be defined as the possible outcomes and the probability distribution of each outcome are known and measurable. In contrast, uncertainty exists when the probability of future outcomes is unknown. However, some economists have argued that the terms risk or uncertainty can be used interchangeably (Dillon & Anderson, 1990; Roumasset, 1976). Risk occurs when the outcome of an operation cannot be forecast with certainty but each outcome can be explained by the subjective probabilities. The authors also argued that risk can be defined as variability of outcomes.

In addition, Kaplan and Garrick (1981) and Kaplan (1997) developed the concept of "Triplets Idea" to define risk in quantitative terms. The definition of risk can be explained to answer three questions; "What can happen?", "How likely is it?" and "What are the consequences?" The term risk is expressed as follows (Kaplan, 1997):

$$R = \{< S_i, P_i(\phi_i), P_i(X_i) >\}_c \; i = 1,2,...,N \tag{1.1}$$

Where:

R is the risk definition,

S_i is the risk scenario,

$P_i(\phi_i)$ is the probability and

$P_i(X_i)$ is the outcome.

Similarly, McCarl and Spreen (1996, pp. 14-11) argued that *"risk considerations are usually incorporated assuming that the parameter probability distribution is known with certainty"*.

McConnell and Dillon (1997) identified uncertainty as a situation when the decision maker has imperfect knowledge. The authors showed how ambiguous outcomes to risk might be envisioned with the probability distribution of each outcome. Hardaker (2000) attempted to clarify the confusion in risk definitions by suggesting three common meanings of risk, which include “the chance of bad outcome”, “the variability of outcomes” and “the uncertainty of outcomes”. Hardaker (2000) argued that risk analysts should examine the total distribution of consequences, whether bad or good, by providing probabilities to prevent confusion when evaluating risk.

Risk in agriculture is pervasive and complex, especially in agricultural production, which can be termed a risky enterprise (Hardaker, Huirne, et al., 2004; Hazell & Norton, 1986). Farmers confront a variety of yields, unstable output and input prices and radical changes in production technology as inherent in their farming operations. These affect the fluctuation in farm profitability from season to season and from one year to another (Dunn, 2002; Hossain, Mustapha, & Chen, 2002). The sources of risk and level of its severity can vary according to farming systems, geographic location, weather conditions, supporting government policies and farm types. Risk is a major concern in developing countries where farmers have imperfect information to forecast things such as farm input prices, product prices, and weather conditions, that might impact the farms in the future (Hazell & Norton, 1986; Nyikal & Kosura, 2005; Pannell, Malcolm, & Kingwell, 2000).

Sources of risk in agriculture are classified into *business risk* and *financial risk* (Hardaker, Huirne, et al., 2004; Harwood et al., 1999). Business risks directly affect the profitability of the farms (Hardaker, Huirne, et al., 2004). These risks can be categorized as *production or yield risk* and are defined as the uncontrollable factors that influence the amount and quality of farm production, including unpredictable weather, drought, diseases and insects (Dillon & Anderson, 1990; Hardaker, Huirne, et al., 2004). These factors can vary depending on the geographical area where each farm is located (Pellegrino, 1999). *Marketing* or *price risk* is described as the fluctuation in the price of farm inputs and outputs affected by demand and supply in the competitive markets. These include unpredictability of agricultural supply, the changes in consumer consumption behaviour and incomes, international trade barriers, instability of currency exchange rates and changes in accessibility and price of farm inputs (Hardaker, Huirne, et al., 2004; Shadbolt & Martin, 2005). *Institution* or *policy* and *legal risk* is associated with changes in government policies, new laws and regulations and supporting government programmes that affect farm production as well as farm contractual mechanisms. For example, new restrictions regarding the use of pesticides or drugs on farms that will increase cost of production, income taxes, credit policy and forward contracts (Hardaker, Huirne, et al., 2004; Shadbolt & Martin, 2005). Farmers may be subject to *human* or *personal risk* when farm owners face major life crises or poor health that affects the efficiency of farm management including the availability and reliability of farm labour (Hardaker, Huirne, et al., 2004; Pellegrino, 1999). *Technological risk* is described as the adoption of new techniques in agricultural production that lead to higher farm profitability but also higher risk if the new techniques are ineffective (Moschini & Hennessy, 2001; Shadbolt & Martin, 2005). On the other hand, *financial risk* occurs when farmers borrow to finance farm activities. In other words, financial risk can be described as the variability of net farm income to the farmers' equity, often affected by leverage. Farmers face variations in interest rates on borrowed funds, inadequacy of cash flow for debt payments and changes in credit terms and conditions; these factors also create considerable financial risk (Narayan, 1990; Shadbolt & Martin, 2005).

Awareness of risk in global agriculture has occurred in many countries. Global-warming, caused by the radical changeability in weather patterns, El Nino, and other natural disasters, including drought and floods, are recognized as major risk factors. These factors affect world production of farm products, particularly in the rain-fed production areas found in developing countries, which results in fluctuation of prices of the products (Adesina & Ouattara, 2000; Harris, Benson, & Rosson, 1999; International Institute for Applied Systems Analysis [IIASA], 2002). Other global agricultural risk factors include changes in consumer consciousness that directly influence the demand for farm products and changes in government policies that affect the cost of production (Harris et al., 1999). The types and severity of risks that farmers face differ from place to place. Incorporating and understanding the effects of risk at the farm level will benefit policy makers who develop the appropriate strategies that can help farmers survive the numerous risks they confront.

For several decades, agricultural production in Thailand has faced many problems including risk such as variability in yields, product-prices and cost of inputs (Katikarn, 1981; Patamakitsakul, 2006; Sayaphan, 2001). Thai farmers normally grow their crops in rain-fed conditions due to poor irrigation systems (Kermel-Torrès, 2004). The annual rainfall fluctuates widely each year, pests, diseases and poor soil fertility affect the yields of cash crops in Thailand (see Table 1.1). In addition, agricultural commodity prices rise and fall annually depending on the demand and supply in both local and international markets, which are out of the farmer's control (see Table 1.2). Similarly, the costs of farm inputs also vary each year and may negatively affect farm production costs.

Table 1.1 Annual average yields and coefficients of variation (CV) for important crops of Thailand, 1998-2006

Product	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*CV*[a]
Rice	397	388	418	419	432	464	457	474	467	7.30
Cassava	2,389	2,479	2,697	2,805	2,731	3,087	3,244	2,749	3,375	11.72
Maize	535	568	588	598	590	617	619	613	633	5.05
Rubber	224	229	249	268	271	286	290	282	282	9.37
Sugarcane	9,058	8,776	9,466	9,042	9,496	10,429	9,269	7,434	7,899	9.87
Soybeans	234	227	232	236	238	246	238	250	250	3.37

[a] $CV = \left(\frac{SD}{\bar{X}}\right) \times 100$ where SD = Standard deviation and $\bar{X}$ = Arithmetic mean

Unit: kilograms per rai
1 rai = 0.16 ha

Source: Office of Agricultural Economics (2009)

Table 1.2 Annual average prices at farm level and CV for important crops of Thailand, 1998-2006

Product	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*CV*[a]
Rice	5.32	4.73	4.35	4.82	5.05	5.57	6.65	6.92	6.83	17.53
Cassava	1.31	0.91	0.63	0.69	1.05	0.93	0.80	1.33	1.29	27.04
Maize	3.70	4.31	3.82	3.95	4.14	4.43	4.59	4.78	5.45	12.50
Rubber	22.73	18.12	21.53	20.52	27.69	37.26	44.13	53.57	66.24	48.81
Sugarcane	0.48	0.50	0.44	0.51	0.43	0.47	0.37	0.52	0.69	18.02
Soybeans	9.45	8.84	9.22	9.38	10.40	10.79	10.88	10.15	10.72	7.71

[a] $CV = \left(\frac{SD}{\bar{X}}\right) \times 100$ where SD = Standard deviation and $\bar{X}$ = Arithmetic mean

Unit: baht per kilogram
1 US$ = 35 baht
Source: Office of Agricultural Economics (2009)

Large numbers of farmers in rural Thailand still live below the poverty line. In 2004, Thai farm households earned an average income of 115,875 baht/year (US$ 3,310); only 38 per cent or 43,883 baht/year (US$ 1,254) is from farm activities (Office of Agricultural Economics [OAE], 2009). Thai farmers are basically smallholders and the national farm size is approximately 7.72 acres (see Table 1.3) (National Statistical Office of Thailand [NSO], 2006). Most farmers have limited diversification potential, face resource problems, environmental variability, lack of soil fertility and water shortages especially smallholder farmers in the north-east region (Lovelace, Subhadhira, & Simaraks, 1988). In addition, smallholder farmers in Thailand also face various sources of risk that vary both seasonally and annually. These risks affect the variability of farm profitability and farm household income.

Table 1.3 Farming area and average farm size categories by Thai region in 2003

Region	*Farming area*		*Number of holding*		*Average farm size*
	Area (acre)	*%*	*Person*	*%*	*(acre)*
Central	8,604,859	19.2	815,962	15.0	9.56
North	9,982,355	22.3	1,286,360	23.6	7.32
North-east	20,281,709	45.3	2,488,253	45.7	7.68
South	5,910,872	13.2	853,335	7.3	6.68
Whole Kingdom	44,779,795	100.0	5,792,522	100.0	7.72

Source: National Statistical Office (2006)

Agriculture contributes approximately 9 per cent to Thailand's GDP and 8.9 per cent to exports (Bank of Thailand [BOT], 2008; Ministry of Finance [MOF], 2008). Risk management strategies, such as hedging, crop insurance and contracting were discussed in the 10th National Economic and Social Development Plan (2007-2011) designed to enhance farmers' ability to cope with risk (Patamakitsakul, 2006). Crop insurance scheme attempts to reduce the risk that Thai farmers confront. However, this scheme offers limited coverage for some major cash crops such as rice and maize, and the crop insurance is mostly based on the weather index. The Thai government has tried to encourage rice farmers to involve in the crop insurance scheme for the crop year 2011-2012. The premiums would be roughly 140 baht per rai and the government will provide damage compensation around 1,400 baht per rai. This project aims to cover approximately 57 million rais in rice growing area (Theparat, 2011). However, rice farmers and insurance companies have been slow to join the crop insurance scheme due to the lack of clear definitions in the scheme and rules regarding the criteria for evaluation of natural disasters (Asia Insurance Review, 2011).

Knowledge of the character of risks that influence smallholder farmers is the key to developing appropriate solutions to deal with risks. However, empirical studies on farmers' responses to risks and how risk affects farmers' income, especially in rural Thailand are limited. Katikarn (1981) conducted a study using a quadratic programming model to test the hypothesis that farmers in central Thailand displayed risk-averse behaviour. The results showed farmers in the central region were risk averse. However, there are many limitations in the research that may have distorted the author's results. These include low estimated variation in yields, ignoring the capital constraints and focusing on only rice production. Phuphak (1993) investigated the optimal area for diversified mango production into lowland traditional rice farms in central Thailand to help farmer lower risk. Multi-period linear programming with the MOTAD risk form was applied in the author's study. The results showed suitable mango production areas vary and depended on the farmer's socioeconomic situation; they were profitable for large and medium rice farms but not feasible for small rice farms.

Research Problem

Risk plays an important role in Thailand's agriculture and the risk environment has changed rapidly recently. Thai farmers experience unpredictable yields and input-output price variability. The pervasive pressure and complications of risk in Thailand agriculture has caused many small farm household incomes to fluctuate yearly.

The purpose of this study is to examine the effects of risk on smallholder farmers' net farm income in the central and north-east regions of Thailand. The optimal risk efficient farming system under uncertainty is investigated for smallholder farmers in each region to achieve the maximum expected income with low variability, subject to the limitation of farm resources.

The central and north-east regions differ in terms of resources, economic development and income distribution. The central region has a farming area of 8.61 million acres or 19.2 per cent of the total farming area. The average monthly income per farmer in this region is 3,711 baht (see Table 1.4) (NSO, 2006). The central region is known as the 'rice bowl of Thailand' and more than half of the country's irrigation systems are located in this region of wet-rice agriculture (Sirisup & Kammeier, 2003). In contrast, the north-east region is defined as the 'poorest region' with a long dry season and an annual rainfall that fluctuates widely each year (Kermel-Torrès, 2004; Lovelace et al., 1988). Approximately 45 per cent of the total farming area in Thailand is located in this region. The average monthly income of the farmers in this region is 1,439 baht (NSO, 2006).

Table 1.4 Average monthly income per person in Thailand in 2000, 2002 and 2004

Region	*Agriculture*			*Non-agriculture*		
	2000	*2002*	*2004*	*2000*	*2002*	*2004*
Bangkok	3,618	4,731	4,626	7,754	8,631	8,262
Central	2,490	2,829	3,711	4,117	4,496	4,900
North	1,296	1,662	1,979	3,067	3,579	4,496
North-east	955	746	1,439	2,768	2,944	2,646
South	1,960	2,003	3,369	3,397	3,854	4,151
Whole Kingdom	1,688	2,050	2,956	4,025	4,658	4,586

Unit: baht/person/month
1 US$ = 35 baht

Source: National Statistical Office (2006)

Several theoretical approaches have been developed to incorporate risk into farm decision making analysis (Dillon & Anderson, 1990; Hardaker, Huirne, et al., 2004; Hazell & Norton, 1986; Moschini & Hennessy, 2001). The level of complexity and detail of each approach depends on the level of interest and the availability of data (Adesina & Ouattara, 2000). Torkamani (2005, p. 140) summarized that those theoretical approaches varied from "*optimization based on linear, non-linear and dynamic programming, to non-optimization such as risk efficient, Monte-Carlo programming to risk programming"* with both embedded and non-embedded risk.

In analysing risky alternatives on farms requires proper information, both probabilities of the outcomes and the farmers' preferences (Hardaker, Richardson, Lien, & Schumann, 2004; Lien, Stordal, Hardaker, & Asheim, 2007). Accordingly, the subjective expected utility hypothesis (SEU) is the most suitable theory for prescriptive assessment of risky alternatives (Hardaker, Richardson, et al., 2004).

Lien et al.(2006, p. 393) defined the SEU theory as *"a rational person will seek to make risky choices consistently with what they believe, as measured by their subjective probabilities, and with what they prefer, as evaluated via their utility functions for consequences"*. In other words, the shape of the utility function reflects an individual's preference toward risk (Hardaker, Huirne, et al., 2004; Lien et al., 2006). However, the difficulties in evaluating and classifying farmers' attitudes toward risk have resulted inaccuracy of some of the agricultural risk analysis studies in the past (Hardaker, Huirne, et al., 2004). Stochastic dominance or efficiency criteria have been developed to help risk analysts avoid a specific single-value utility function (Hardaker, Richardson, et al., 2004).

Stochastic efficiency with respect to a function (SERF) is the up-to-date method for ranking risky alternatives employed in this research. The SERF ranks the set of risky farming systems in terms of certainty equivalents (CE) over a range of risk aversion levels (Hardaker, Huirne, et al., 2004). Lau (2004, p. 41) argued that "*CE is the amount of money a decision maker would be willing to pay for a fair bet versus a risk free alternative with the same mean return*". The CE can be converted to a monetary value by taking the inverse of the utility function (Hardaker, Richardson, et al., 2004). This method illustrates which risky alternative is preferred by farmers who are least risk-averse, moderately risk-averse, or extremely risk-averse (Hardaker, Richardson, et al., 2004; Lien et al., 2006). Moreover, Lien et al.(2007, p. 1586) argued that *"SERF is more transparent, easier to implement, and has stronger discriminating power than conventional stochastic dominance with respect to a function (SDRF)"*.

SERF is used to compare the simulated empirical probability distributions of annual net farm revenue for smallholder farmers in central and north-east Thailand in this study. The SERF has been used in previous studies, especially to rank risky alternatives on farm, see for example, Lien et al.(2006); Lien, Hardaker and Flaten (2007); Lien, Stordal et al.(2007); Pendell, Williams, Boyles, Rice and Nelson (2007).

The SERF method is employed to evaluate and compare the set of risky farming systems in each study area to identify the best risk efficient farming system. The appropriate risk efficient farming system will help smallholder farmers to cope better with risks. The results from this research should guide Thailand's agricultural policy-makers in producing effective policies to sustain smallholder farmers' livelihoods.

1.2 Research objectives

The issue of risk analysis on farms in evaluating the optimal risk efficient farming system has been well reported in the agricultural economics literature. However, there is little published empirical evidence about risks at the farm level in Thailand's agriculture. This research examines the risk sources and the effects of risk on the net farm income of smallholder farmers in the central and north-east Thailand. The differences in environmental resources and economic development between these two regions are used to compare the results.

The research objectives are to:

1. provide an overview of the risk efficiency measurement literature which can explain the effect of risk on Thailand farming systems;
2. identify and analyse the importance sources of risk on farm and the uses of risk management strategies among smallholder farmers in central and north-east Thailand;
3. estimate the risk preferences of the smallholder farmers in central and north-east Thailand;
4. investigate the best alternative risk efficient farming system for smallholder farmers in central and north-east Thailand; and
5. provide policy implications from the findings.

1.3 Contributions of the research

The findings of this study can provide useful information to reinforce the empirical basis for risk analysis for Thai farmers. This research explores the currently important risk sources that confront smallholder farmers in the central and north-east regions and their risk management strategies. The results will provide more accurate information regarding risk at the farm level to policy makers and researchers.

Further, this research seeks to investigate the risk attitudes of the smallholder farmers in both regions. Risk preferences influence farmers' decision making on farms and can be used as a basis for farm risk analysis research. Therefore, this research finding would enhance the risk knowledge pertaining to Thai smallholder farmers' risk behaviour.

Thailand's smallholder farmers have experienced pervasive complications of risks that caused farm income to fluctuate from year to year. Undeniably, farmers also prefer to maximize net farm income with low variability. However, smallholder farmers, especially in rural areas, have limited ability to choose appropriate alternative farming systems to stabilize their income. In the past, when comparing alternative farming systems most studies focused on the expected profitability and did not pay attention to differences in the riskiness of the farming systems (Lien, Hardaker, et al., 2007). It seems likely that the farmers' decision making on choices of alternative farming systems should account for the impact of risk. Therefore, another main contribution of this research relates to the evaluation of the most appropriate risk efficient farming system alternative using stochastic simulation within stochastic efficiency criteria. This risk efficient farming system would facilitate smallholder farmers in both regions to better cope with risk and improve their farm income.

Overall, this research is expected to raise the awareness of risk on farms in policy makers. The better the understanding of the effects of risk at the farm level, the more appropriate will the policies be that are constructed. These policies would help farmers confront the numerous risks they deal with everyday.

1.4 Structure of the research

The rest of this thesis is structured as follows. Chapter Two provides a brief historical background of Thailand agricultural systems and the sources of risk that typically faced by farmers. Chapter Three reviews the literature on the expected utility theory, utility elicitation techniques and the risk efficiency approaches. Chapter Four discusses the research methodologies and survey procedures. Chapter Five presents the empirical results and discusses the findings of the perceptions of sources of risk and risk management strategies. The results of the stochastic risk efficiency analysis are discussed in Chapter Six. Chapter Seven concludes the thesis with a summary of the main research findings, policy implications followed by the limitations of the research and recommendations for future study.

Chapter 2
Thailand Agriculture

This chapter provides a brief historical background of Thailand agriculture, farming systems and the on-farm risks that Thai farmers typically face. The chapter is organized as follows. Section 2.1 discusses the general background of the agricultural sector in the Thai economy. The performance and problems of Thailand agriculture are discussed in Section 2.2. Section 2.3 discusses the farming systems in Thailand. Section 2.4 discusses the sources of risk and risk management strategies that influence small scale farming.

2.1 General background

Thailand is similar to several other developing countries in that the country's economic development is based on agriculture. Over recent decades, agriculture has been the mainstay of the Thai economy. In 2007, the agricultural sector represented nearly 9 per cent of Thailand's gross domestic product (GDP) and around 8.9 per cent of exports (BOT, 2008; MOF, 2008). Agricultural exports are an important part of Thailand's GDP but the contribution has declined. Poapongsakorn, Anuchitworawong, and Mathrsuraruk (2006) argued that the agricultural sector is the largest sector in terms of the nation's primary workforce employment, the principal source of export earnings and GDP share. It also represents Thailand's rural livelihood.

The value of Thailand's agricultural exports was estimated at 1,129.2 billion baht in 2007 (OAE, 2008). As one of the world's major agricultural exporters, Thailand leads the world in the export of rice, cassava and natural rubber. In 2005, Thailand rice exports accounted for almost US$ 2.3 billion or 24.3 per cent of the world's total rice exports (Food and Agriculture Organization of the United Nations [FAO], 2008b). Thailand exports of cassava equalled almost US$ 0.56 billion or 70.4 per cent of the world's total cassava exports. In the global natural rubber market, Thailand was the top exporter among major exporters, such as Indonesia and Malaysia, with exports valued at nearly US$ 3.7 billion or 40.9 per cent of the world's total natural rubber export (see Table 2.1). In addition, Thailand is among the top 10 exporters of sugar, poultry meat, frozen shrimps and pineapple.

Table 2.1 World's Exports of Crops (selected countries), 2005

Rice	*Value*	*Share (%)*	*Cassava*	*Value*	*Share (%)*	*Natural Rubber*	*Value*	*Share (%)*
Thailand	2,327.66	24.31	Thailand	559.47	70.38	Thailand	3,704.22	40.88
India	1,411.15	14.74	Vietnam	61.34	7.72	Indonesia	2,583.96	28.51
Vietnam	1,407.23	14.70	Indonesia	44.84	5.64	Malaysia	1528.12	16.86
USA	1,290.70	13.48	Costa Rica	43.92	5.53	Vietnam	244.52	2.70
Pakistan	930.76	9.72	China	15.12	1.90	Cote d'Ivore	200.12	2.21
World	9,574.32	100.00		794.93	100.00		9,061.92	100.00

Unit: million US$

Source: Food and Agriculture Organization of the United Nations (2008b)

Thailand, the geographical heart of the Indo-Chinese peninsula, borders Laos to the north and north-east, Myanmar to the north and west, Cambodia to the south-east, and Malaysia to the south. The main feature of Thailand's physical structure is that it is divided into four natural regions (see Figure 2.1). The northern mountainous region comprises a series of north-south ridges and narrow valleys interspersed with long flat river basins. The central region is a low-lying area that contains large alluvial plains surrounding the Choa Phraya River, the core river system of the country. This region is conducive to intensive cultivation. The north-east occupies nearly 45 per cent of the total area of the country comprising the wide river terraces of the Mekong River and its tributaries and the semi-arid Khorat Plateau. This region is generally characterized by low fertility soils and erratic rainfall. The south of the country consists of rolling and mountainous terrain with narrow coastal plains (Falvey, 2000; Kermel-Torrès, 2004; Panusittikorn & Prato, 2001).

The climate in Thailand is classified as tropical rainforest and tropical savanna with characteristically high temperatures and humidity. There are three main seasons in Thailand with no significant difference in temperature between seasons. The hot season is mid February to mid May, the rainy season is from mid May to mid October and the cool season is from mid October to mid February. The average temperature range of the country is 26-28 °C in the cool season and 28-32 °C in the hot season (Falvey, 2000). Rainfall is dominated by monsoons and cyclones. The average annual rainfall ranges from 1,400 mm in the north-east to 2,700 mm in the south (Thai Meteorological Department [TMD], 2008). However, Thailand has experienced wide seasonal climatic fluctuations. Drought is one of the main critical crises in agricultural production. Each year, some cultivated areas are damage by uneven annual rainfall especially in the north-east region (Department of Agricultural Extension [DOAE], 2007).

Figure 2.1 Map of Thailand

Source: United Nations (2008)

With regard to land utilization, Thailand covers 321 million rais (51 million hectares); with the total cultivated area estimated at 131 million rais (about 41 per cent), the forests cover some of 105 million rais (about 33 per cent) and the rest is considered as non-agriculture area (see Table 2.2) (OAE, 2009). According to the 2003 National Agricultural Census, 52.3 per cent of the total arable area (about 59 million rais) is used for rice production, 19.1 per cent (about 22 million rais) for field crops, 11.7 per cent (about 13 million rais) for permanent crops and 8.6 per cent (about 10 million rais) for para rubber (NSO, 2006).

Traditional crop production in Thailand is severely impacted by rainfall and flood water. The irrigation and drainage system in Thailand has been poorly developed (Falvey, 2000). The most important irrigation network development of the country is located in the Chao Phraya basin. During 1960s, large-scale multipurpose dams were constructed in the central plain under the water resource development schemes financially supported by the World Bank. The project was developed to generate hydroelectric power, expand the cultivated areas of lowland rice and supply water for the industrial sector. Conversely, the north-east faces water deficiency. The topography itself is inappropriate for large scale irrigation projects (Kermel-Torrès, 2004; Lovelace et al., 1988). According to the Royal Irrigation Department statistics, in 2007, approximately 28 million rais or 21 per cent of the total arable land was categorized as irrigated. Approximately 41 per cent of the total irrigated area is found in the central area, 22 per cent in the north-east, 18 per cent in the north and 10 per cent in the south (Royal Irrigation Department [RID], 2008).

Table 2.2 Land utilization of Thailand, 1997-2005

Year	*Total area (rai)*	*Forest area*		*Arable area*	
		Area (rai)	*%*	*Area (rai)*	*%*
1997	320,696,888	81,441,164	25.39	131,107,608	40.88
1998	320,696,888	81,076,428	25.28	130,393,525	40.66
1999	320,696,888	80,610,219	25.13	131,341,384	40.95
2000	320,696,888	100,638,200	31.38	131,195,913	40.91
2001	320,696,888	106,319,188	33.15	131,059,974	40.87
2002	320,696,888	106,319,188	33.15	130,892,013	40.81
2003	320,696,888	106,319,188	33.15	130,682,027	40.75
2004	320,696,888	104,744,313	32.66	130,480,283	40.69
2005	320,696,888	104,744,313	32.66	130,275,993	40.62

1 rai = 0.16 ha

Source: Office of Agricultural Economics (2009)

The population of the country in 2006 was estimated at 62.83 million and the population growth rate was 0.7 per cent (NSO, 2007). According to the 2000 Thailand Population Census, the population density is estimated at 120.6 persons per square kilometre. In 2006, almost 40 per cent of the Thai population lived in rural areas and was engaged in agriculture (see Table 2.3). There were approximately 5.785 million farm households (OAE, 2009). Thus, agriculture in Thailand is characterised by a large number of smallholder farmers. Since the 1990s, Thailand agriculture has faced low productivity and a shortage in the agricultural labour force because of the severe droughts and the wage gap between rural and urban areas. This led to an increase in permanent and seasonal rural-to-urban migration (Fuglie, 2001; Thaiprasert, 2006). Employment in the agriculture sector fell from nearly 70 per cent of the total labour force in 1980 to 51 per cent in 1998 (Thaiprasert, 2006). In 2006, 43.3 per cent of the working population resided in agriculture and agro-industries (see Table 2.3) (OAE, 2009).

Table 2.3 Population and employment statistics of Thailand, 2002-2006

Year	*Population*			*Employment*		
	Total	*Agriculture*	*Non-agriculture*	*Total*	*Agriculture*	*Non-agriculture*
2002	62.79	25.72 (40.9%)	37.07 (59.1%)	34.60	16.57 (47.9%)	18.03 (52.1%)
2003	63.08	25.64 (40.6%)	37.44 (59.4%)	35.48	16.31 (45.9%)	19.17 (54.1%)
2004	61.97	25.53 (41.2%)	36.44 (58.8%)	36.01	15.29 (42.5%)	20.71 (57.5%)
2005	62.42	25.36 (40.6%)	37.05 (59.4%)	36.55	15.77 (43.1%)	20.78 (56.9%)
2006	62.83	25.16 (40.1%)	37.66 (59.9%)	36.58	15.83 (43.3%)	20.75 (56.7%)

Unit: million people

Source: Office of Agricultural Economics (2009)

In 2007, Thailand's GDP was 4,244.5 million baht with a 4.8 per cent growth rate; agriculture accounts for approximately 9 per cent of the GDP (see Table 2.4) (BOT, 2008). The proportion of the primary agriculture sector to the GDP has dropped dramatically from 38 per cent in 1951, 27 per cent in 1970 to roughly 9 per cent in the 2006. In the late 1980s, the rapid growth and development of the country's economic base came from foreign direct investment in the industrial and service sectors. Thailand developed into a semi-industrial country during that time. This transformation in the country's economic structure affected the GDP. For example, the contribution of the industrial and services sectors to the GDP rose from 62 per cent in 1951 to nearly 90 per cent in 2007. This may be one of the several causes of the decline in importance of agriculture in the Thai economy (Falvey, 2000; Limsombunchai, 2006; Thaiprasert, 2006). However, agriculture continues to be a major source of raw materials for the industrial sector especially in the agro-industry, industrialized food products and beverages, and intermediate products for import substitution and export. This includes cassava for the livestock feed industry, sugarcane for sugar refining, and natural rubber for latex factories (Fuglie, 2001).

Table 2.4 GDP of Thailand 1988-2007 by sector at constant 1988 prices

Year	*Gross domestic product*				
	Agriculture	*%*	*Non-agriculture*	*%*	*Total*
1988	252.3	16.18	1,307.4	83.82	1,559.8
1989	276.5	15.80	1,473.3	84.19	1,749.9
1990	263.6	13.55	1,681.7	86.45	1,945.3
1991	282.7	13.39	1,829.1	86.61	2,111.8
1992	296.2	12.98	1,986.3	87.02	2,282.5
1993	289.0	11.70	2,181.8	88.30	2,470.9
1994	303.3	11.26	2,389.6	88.74	2,692.9
1995	276.5	9.40	2,665.1	90.60	2,941.7
1996	288.8	9.27	2,826.5	90.73	3,115.3
1997	286.8	9.33	2,785.7	90.66	3,072.6
1998	282.6	10.28	2,467.0	89.72	2,749.6
1999	289.1	10.07	2,582.8	89.93	2,871.9
2000	309.9	10.30	2,698.4	89.70	3,008.4
2001	320.0	10.41	2,753.5	89.59	3,073.6
2002	322.1	9.95	2,914.8	90.05	3,237.0
2003	363.0	10.47	3,105.1	89.53	3,468.1
2004	354.4	9.61	3,333.7	90.39	3,688.1
2005	347.8	9.02	3,507.2	90.98	3,855.1
2006	361.1	8.91	3,690.8	91.09	4,052.0
2007	375.4	8.84	3,869.1	91.16	4,244.5

Unit: million baht

Source: Bank of Thailand (2008)

Since 1963, agricultural improvement policies have been highlighted in the National Economic and Social Development Plans. In the mid 1980s, the Thai government started the new concept of “Newly Agro-Industrializing Country” (NAIC). Several key policies were implemented to enhance the country’s comparative advantage in the export of traditional crops and new agro-industrial product exports such as chilled and frozen prawns, broilers and canned food (Thaiprasert, 2006). Thailand earned a large amount of foreign exchange from the export of these products. The value of agricultural exports has risen from 224.17 billion baht in 1990 to 1,129.21 billion baht in 2007 (see Table 2.5). However, Thailand’s agricultural exports are still dominated by primary crop production and this varies from year to year. In 2007, traditional agriculture comprised nearly 64 per cent of the total value of exports, 35 per cent for agro-industrial products and the rest for forestry products (see Table 2.6). Rice, natural rubber and fishery products were the three most important commodities, contributing more than half the total value of agricultural exports in 2007 (see Table 2.7). Thailand’s major agricultural export destinations include the United States (16 per cent), Japan (15 per cent), China (12 per cent), European Union (10 per cent) and Malaysia (7 per cent) (OAE, 2008).

Table 2.5 Value of exports, imports and balance of trade of Thailand, 1990-2007

Year	*Export*		*Import*		*Balance of trade*	
	Total	*Agricultural and product*	*Total*	*Agricultural and product*	*Total*	*Agricultural and product*
1990	589,818	224,168	662,679	102,244	-263,144	98,458
1991	725,449	256,038	852,962	125,710	-230,959	113,169
1992	824,643	285,264	956,408	142,869	-208,602	126,810
1993	940,862	279,857	1,033,245	158,454	-229,984	119,968
1994	1,137,601	336,290	1,170,846	159,889	-231,433	156,433
1995	1,406,310	407,218	1,369,034	179,857	-428,227	193,680
1996	1,411,039	412,677	1,834,537	213,538	-421,786	195,844
1997	1,806,932	485,198	1,832,825	216,833	-117,331	256,367
1998	2,242,543	519,062	1,774,050	226,827	474,727	364,863
1999	2,209,458	555,783	1,907,391	228,098	306,858	328,400
2000	2,764,352	626,286	2,494,133	275,459	273,931	351,452
2001	2,880,463	685,148	1,752,346	323,320	132,358	363,064
2002	2,923,941	394,403	2,774,840	325,961	155,333	369,935
2003	3,325,630	804,349	3,138,776	363,374	192,316	441,922
2004	3,873,689	883,177	3,801,067	398,356	768,087	485,315
2005	4,438,691	936,519	4,754,025	437,576	-307,659	499,623
2006	4,937,372	1,071,543	4,942,923	434,541	1,627	637,390
2007	5,254,999	1,129,206	4,871,996	456,743	388,616	672,742

Unit: million baht

Source: Office of Agricultural Economics (2008)

Table 2.6 The value of the agricultural exports of Thailand, 2004-2007

Items	*2004*	*2005*	*2006*	*2007*	*Growth rate*
Total exports value	3,873.69	4,438.69	4,937.37	5,265.29	12.32
Agricultural and products	886.15	936.52	1,071.54	1,129.21	9.07
- Agriculture	563.22 (63.56%)	587.83 (62.77%)	694.78 (64.84%)	730.52 (64.70%)	10.45
- Agro-industrial products	321.58 (36.29%)	347.52 (37.11%)	375.23 (35.02%)	397.66 (35.21%)	6.77
- Forestry	1.35 (0.15%)	1.17 (0.12%)	1.53 (0.14%)	1.03 (0.09%)	0.30

Unit: billion baht

Source: Office of Agricultural Economics (2008)

Table 2.7 The structure of Thailand's agricultural exports (selected products), 2004-2007

Items	*2004*	*2005*	*2006*	*2007*	*Growth rate*
Rice	104.49	83.85	87.24	107.34	6.16
Cassava products	23.24	22.14	31.25	32.36	15.97
Sugar and products	23.24	30.70	29.70	41.21	-1.03
Natural rubber	148.84	162.70	228.88	198.72	14.73
Pineapple products	16.97	18.08	20.24	17.68	2.13
Livestock products	23.27	28.50	30.33	34.10	-1.27
Fishery products	84.89	101.37	109.49	109.66	7.40

Unit: billion baht

Source: Office of Agricultural Economics (2008)

Thailand also imported some agricultural commodities and intermediate products for its domestic consumption. These commodities were extensively used in local food manufacturing and the livestock feed industry because domestic production is inadequate. The import commodities included soya beans and products, fresh tuna, dairy products, and rubber products (see Table 2.8). The value of agricultural imports was 456.74 billion baht or around 9 per cent of the total value of imports in 2007 (see Table 2.5).

Table 2.8 The structure of Thailand agricultural imports (selected products), 2004-2007

Items	*2004*	*2005*	*2006*	*2007*	*Growth rate*
Rubber products	26.09	31.27	34.72	35.07	11.15
Soya beans and products	34.85	37.95	33.67	41.09	1.54
Milk products	12.18	13.64	13.19	16.19	9.73
Fishery products	50.73	59.75	60.63	61.43	7.25

Unit: billion baht

Source: Office of Agricultural Economics (2008)

The above discussion strongly demonstrates the importance of the agricultural sector to the Thai economy. To begin with, agriculture is the main source of income and employment for the people who live in rural areas and reflects the rural livelihood. Later, the agricultural sector afforded food security for the Thai population and for the world. Moreover, it supplied raw materials to the industrial sector, especially agro-industry, to enhance the country's export potential. Finally, agricultural export commodities also provide a great source of the country's foreign exchange earnings.

2.2 Performance and problems of Thailand agriculture

Thailand's agricultural sector has shown outstanding growth during the previous three decades. During 1960s and 1970s, the country's economy relied heavily on traditional agriculture. The agricultural sector at that time experienced rapid growth of nearly 5 per cent per annum (see Table 2.9) (Poapongsakorn et al., 2006). With this relatively high growth rate in the agricultural sector, the government persuaded Thai farmers to expand their cultivated areas to grow cash crops, such as rice, maize, sugarcane, and cassava, to increase the farmers' income. The government also supported irrigation systems, extension services, production credit, and financial investment to help farmers enhance their farm productivity (Vanichjakvong, 2002).

Thailand's agricultural production underwent major changes during the 1970s. Thai farmers experienced intensive production and market orientation (Gingrich, 1994). However, the expansion of the cultivated areas caused severe deforestation. For example, Krasachart (2003) argued that the country has lost nearly 28 per cent of the forested areas during 1976 to 1989.

The agricultural growth rate declined during the 1980s mainly because of the falling world agricultural prices and farm land expansion had reached saturation point (Poapongsakorn et al., 2006; Vanichjakvong, 2002). In addition, tariff and non-tariff barriers on agricultural products, such as the European Economic Community (EEC) import quotas policy and the local rice industry protection policy in the US, along with the Thai government's policies that focused only on the promotion of industrialization caused Thailand's agriculture to lose its competitiveness. The growth rate of primary production, such as rice, maize, cassava, and some field crops, reduced significantly throughout the 1980s (Falvey, 2000; Thaiprasert, 2006).

However, in the mid 1980s, the development of new agro-industrial products, such as frozen chicken, sugar, pineapple, and marine products, became a focus of policy makers. The agro-industrial area has been increasingly recognized as the important driving force in Thailand's economic growth and development. The livestock and fisheries industries experienced rapid growth during that period (see Table 2.9).

Table 2.9 Growth rate of Thailand's agricultural sector and other sectors, 1960-2004

Year	*Growth rate*						
	Industry	*Services*	*Agriculture*	*Crops*	*Livestock*	*Fisheries*	*Forestry*
1960-80	8.82	7.28	5.08	3.87	4.43	9.68	1.96
1980-85	6.45	5.18	4.09	5.04	2.16	3.64	-2.44
1985-90	14.03	9.75	4.05	3.45	6.87	7.87	-10.93
1990-96	9.78	7.84	3.13	2.22	1.80	8.42	-2.65
1996-98	-5.15	0.89	-1.22	0.05	-2.52	-1.65	-21.48
1998	-10.61	-11.98	-1.47	-0.45	-6.89	1.46	-20.11
1999	11.68	0.09	2.68	3.16	1.21	-0.13	-1.74
2000	6.04	3.33	6.81	8.11	6.85	4.81	-2.94
2001	1.35	2.57	3.25	3.57	9.24	-1.73	-1.54
2002	7.35	4.74	0.68	0.55	6.20	-0.17	1.08
2003	10.40	3.60	11.44	10.26	8.01	3.33	-5.73
2004	7.99	6.99	-4.79	-2.98	-17.56	3.63	-9.73
1998-04	6.67	3.57	3.50	4.01	3.80	1.38	-2.97
1960-04	8.97	6.67	3.69	3.48	4.01	5.64	-3.31

Unit: percentage changes

Source: Poapongsakorn et al. (2006)

Thailand's economy suffered heavily following the Asian financial crisis in 1997. The crisis dramatically affected the financial service industry, construction, property market, and some high import-intensity industries (Limsombunchai, 2006). The GDP growth rate declined to the lowest in a decade to nearly -11 per cent in 1998; the industrial and service sectors' growth rate dropped to -10.61 and -11.98 per cent respectively (see Table 2.9). These results raised the inflation rate from 5.7 per cent in 1997 to 18 per cent in 1998. In addition, the unemployment rate also increased. An estimated 600,000 workers lost their jobs in 1997 and another 500,000 were unemployed in 1998. Several of the unemployed urban people returned to the agricultural sector (Lauridsen, 1998).

The agricultural growth rate was -1.5 per cent in 1998. It suffered least from the financial crisis. For example, the value of agricultural exports increased from 412.68 billion baht in 1997 to 485.20 billion baht in 1998. Poapongsakorn et al. (2006) identified three factors that caused the negative growth rate in the agricultural sector during 1997 to 1998 including the El Nino effect, the drop in world agricultural prices and the decline in the livestock and marine fisheries subsectors. This illustrated the natural resources and strength of the agricultural sector as the growth engine of the economy during the financial crisis (Lauridsen, 1998; Limsombunchai, 2006).

During 1998 to 2004, the agricultural sector has maintained sustained growth. The demand for world agricultural products has increased, especially the demand for natural rubber and cassava by China. The average growth rate in the agricultural sector was around 3.5 per cent.

However, in 2002, the EU discovered Nitrofuran in shrimp and chicken exports from Thailand. All import orders from the EU were suspended until the problem was resolved. As a result, there was a significant decline in the growth rate in both the livestock and fisheries subsectors (Nidhiprabha, 2004). In 2004, due to the Avian Influenza (AI) crisis, the growth rate of the agricultural sector dropped to nearly -5 per cent. The livestock subsector experienced a severe decline to -17.56 per cent. According to Rushtona, Viscarraa, Bleicha, and McLeod (2005), nearly 25.9 million birds were culled to control the AI in Thailand. However, consumption recovered after the panic had settled. Poapongsakorn et al. (2006) estimated a 2.6 to 3.0 per cent decrease in agricultural GDP in 2004 as the result of the AI crisis.

The agricultural growth rate averaged 3.9 per cent throughout 2007 (BOT, 2008). However, the agricultural sector growth was estimated at 6.5 per cent in the second quarter of 2008. Crops enjoyed remarkable growth of 11 per cent. This was because the world price of rice rose significantly during the second quarter of 2008. This result encouraged farmers to increase their second crop paddy production. In addition, energy crops, such as oil palm, sugarcane and cassava, had increased demand. In contrast, fisheries decreased in 2007. The growth rate during the second quarter of 2008 was approximately -3 per cent. The higher relative prices for oil caused high input production costs and decelerated the growth in fisheries (The Office of the National Economic and Social Development Board [NESDB], 2008b).

According to Thaiprasert (2006), Thailand's agricultural sector represents two different characteristics. First, it serves as food security not only for Thai people but also for the world, which had enjoyed remarkable growth during the past three decades and provided a large amount of foreign exchange earnings. Second, Thailand's agriculture confronted many problems, such as low production efficiency, rural-urban income gap and lack of credit availability (Krongkaew, 1985; Poapongsakorn, Ruths, & Tangjitwisuth, 1998; Thaiprasert, 2006). The severity of each problem varied considerably from year to year. Some problems were solved by employing short-term agricultural policies but others could not be solved. The pervasive and persistent problems of Thai agriculture include:

I. Rural poverty

The huge gap in the wage rate, personal income and employment between the agriculture and non-agriculture sector has resulted in rural-urban inequality and rural poverty in Thailand (Ahmad & Isvilanonda, 2003). The majority of Thai farmers experience poverty and are below the basic standard of living especially smallholder farmers in the rural areas (Krongkaew, 1985). Nagayets (2005) argued that the World Bank defines smallholder farmers as farmers who have limited resources and operated with a landholding less than 2 hectares (less than 20 rais). The number of farm households in 2003 having less than 20 rais in Thailand was approximately 3.82 million or nearly 65 per cent (NSO, 2006). The remaining 35 per cent of farm households comprise medium and large farmers. In 2007, nearly 90 per cent of the poor lived in the rural areas and two thirds of them lived in the north-east region. Most of the poor are smallholder farmers (Ahmad & Isvilanonda, 2003; NESDB, 2008c).

Wattanutchariya and Jitsanguan (1992) argued that smallholder farmers in rural areas, in general, are not able to choose the most efficient type of production to maximize their farm income and the optimally use of resources because of limited farm size. This resulted in inefficient production and lower farm income. Most poor farmers also have insufficient capital and a lack of production technology (Thaiprasert, 2006). In addition, Limsombunchai (2006) argued that smallholder farmers obtained large loans to sustain their farm production, household consumption, and investment. In 2006, the average net farm household revenue was 115,674 baht per household. Only 39 per cent was from farm activities, the rest came from off-farm income. On the other hand, the average loan size increased from 43,415 baht per household in 2001 to 67,762 baht per household in 2006 (see Table 2.10).

Table 2.10 Average Thailand farm household income, expenditure, net household revenue and loan size, 2001-2006

Items	*2001*	*2004*	*2005*	*2006*	*Growth rate*
Income	135,761	115,542	167,544	174,521	
Farm income	76,520	88,099	99,288	102,907	12.69
Off-farm income	59,241	67,443	68,256	71,614	8.00
Expenditure	104,101	129,733	137,353	148,584	
Farm expenditure	44,392	50,183	56,843	58,847	12.10
Non-farm expenditure	59,709	79,550	80,510	89,737	12.61
Net household revenue	91,369	105,802	110,702	115,674	
Net farm revenue	32,128	38,359	42,445	44,060	13.50
Average loan size	43,415	63,901	65,803	67,762	17.51

Unit: baht/household

Source: Office of Agricultural Economics (2009)

II. Drought

Drought is considered one of the most significant problems causing yield loss particularly in the rain-fed cultivated areas. The drought patterns in Thailand vary across locations and times. The north, north-east and some areas of the central region experience widespread annual drought (Fukai, Pantuwan, Jongdee, & Cooper, 1999).

Jongdee, Pantuwan, Fukai and Fischer (2006) argued that drought affected rice production annually. Similarly, Poltanee (1996) and Fukai et al. (1999) identified yield reduction in rice as a result of drought, which widely affects rain-fed lowland rice production in the north-east. Because of inefficient and inadequate irrigation development, over 70 per cent of the farmers in this region are directly involved in rain-fed rice production and only 8 per cent of the paddy fields can be cropped twice a year (Mongkolsawat et al., 2001).

The DOAE (2007) reported that in 2007 approximately 415,174 rais of cultivated area throughout Thailand were damaged and nearly 40,152 farm households were impacted by serious drought. This resulted in an estimated loss of around 188 million baht.

III. Agricultural commodities' price fluctuations

The price of major agricultural products in Thailand tends to be highly volatile both seasonally and annually. The unpredictability of world agricultural prices directly affected fluctuations in the domestic market (Poapongsakorn et al., 2006). Devakula (2006) identified a general characteristic of agricultural products as *"long supply adjustment lags and inelastic demand"*.

According to Katikarn (1981) and Wiboonpongse and Chaovanapoonphol (2001), Thai farmers are price-takers. A farmer's decisions on crop production planning are based upon his expectations of the current price and the price received from the previous crop. In addition, a traditional farmer cannot control quality and supply. This resulted in poor management of the agricultural price policy in the past and farmers suffered from price risk.

Price fluctuation not only affected Thai farmers but also domestic agricultural processors. The Thai government has attempted to provide effective instruments to improve the management of instability in agricultural commodities' prices. The establishment of the Agricultural Futures Exchange of Thailand (AFET) is one of the tools used by local agriculture stakeholders to hedge excess price risks and arrange pricing references for the public (The Agricultural Futures Exchange of Thailand [AFET], 2007). The AFET commenced futures trading with the three largest agricultural exports. These include natural rubber ribbed smoke sheet No.3 (RSS3) since May 2004, white rice 5 per cent broken (BWR5), and tapioca chips (TC) traded in August 2004 and March 2005, respectively. The new product introduced to the futures market in July 2008 was Thai Homali rice 100 per cent grade B (BHMR). However, agricultural futures trading in Thailand is currently at the developing stage. According to AEFT 2007 trading statistics, there were 89,966 contracts traded from a total market value of 29,932.77 million baht. The RSS3 recorded the highest traded volume followed by BWR5 and TC.

IV. Low productivity

Despite being one of the world's top agricultural exporters, Thailand has low agricultural productivity. Thaiprasert (2006) identified insufficient water resources with poor irrigation systems, inefficient use of fertilizer, low capital inputs and lack of research and development as the main causes for low productivity in major crops in Thailand. The data in Table 2.11 show the yield per hectare of rice, natural rubber and sugarcane in Thailand, which has low range of yields compared with other exports. Productivity improvement is generally discussed among agricultural policy makers because it directly enhances a farmer's real wage and income.

Table 2.11 Yield of major crops in Thailand compared with selected countries, 2005

Rice	*Yield*	*Cassava*	*Yield*	*Natural Rubber*	*Yield*	*Sugarcane*	*Yield*
USA	74,373	India	255,222	Philippines	38,527	Peru	1,105,481
Japan	66,483	Thailand	171,803	Mexico	19,540	Columbia	936,012
Australia	66,167	Indonesia	159,224	Cote d'Ivore	17,958	Australia	871,573
Vietnam	48,833	China	154,037	India	17,844	Philippines	851,077
Pakistan	31,741	Vietnam	153,558	Thailand	17,598	Indonesia	813,888
Thailand	29,625	Costa Rica	150,224	China	11,050	Thailand	464,620

Unit: hectogram/hectare

Source: Food and Agriculture Organization of the United Nations (2008a)

2.3 Farming systems in Thailand

The farming systems in Thailand are characterized by intensive rice-based cropping system because rice is the important staple food crop of Thai people (Ahmad & Isvilanonda, 2003). According to Devendra and Thomas (2002), the single lowland rice crop under rain-fed conditions is the main crop product for smallholder farmers in South-east Asian countries including Thailand. Rice production, which is identified as a *"low-input-output farming system"* begins during the rainy season. Poltanee (1996) argued that rice-based cropping systems are generally practised in the rain-fed areas of north-east Thailand.

On the other hand, commercial crop production systems in Thailand have been greatly diversified. This includes rice, field crops, perennial tree crops, vegetables, herbs and cut flowers (Ministry of Agriculture and Cooperatives [MOAC], 2008). Ordinary farming systems that are widely practised in each region of Thailand include (Chainuvati & Athipanan, 2001):

- North: the upland rice-upland annual field crop systems (such as soybean, maize, and mungbean) are in the mountainous areas of this region. Fruit tree-based cropping systems (such as lychee, longan, and mango) are intercropped with upland field crops; vegetables and flowers are widely grown.

- North-east: the lowland single rice crop systems are typically planted in the rain-fed areas during the rainy season. Dry land field crops (such as cassava, kenaf, and sugarcane) are perhaps grown either before or after the main rice production. Multiple rice crop systems are followed by annual field crops (such as soybean, mungbean, and peanuts), and crop-livestock-freshwater fish integrated farming systems are also practised on small mixed farms in irrigated areas. Perennial tree crop systems based on rubber, eucalyptus, and fruit trees are particularly grown in some rain-fed areas.

- Central: multiple rice crop systems are grown annually. Two or three lowland rice crops are followed by field crops and vegetables (such as baby corn, cucumber, and yard long bean) in irrigated areas. Livestock and fisheries are also integrated with crops in diversified farming systems. For rain-fed areas, the cropping pattern is lowland rice followed by field crops. Therefore, the ordinary farming patterns in this region are rice-based and field crop-based cropping systems.

- South: rubber-based farming systems intercropped with upland rice, sweet corn, pineapple, and upland field crops are extensively planted in the south. In addition, marine fisheries and shrimp farming are important for farmers in coastal areas.

According to the Office of Agricultural Economics statistics, the growth rate of energy crop production (oil palm, cassava, and sugarcane) has become increasingly significant compared with rice and field crop production (maize and soybean) during 2003-2007. Rapid growth of energy crop production was possible because of the high demand for those crops to process into biodiesel and gasohol. Perennial tree crops (rubber and longan) are also planted. However, Thai farmers are faced instability of yields in major cash crops (see Table 2.12).

Table 2.12 Harvested area, production and yield of selected cash crops in Thailand, 2003-2007

Crops	*Items*	*2003*	*2004*	*2005*	*2006*	*2007*	*Growth rate*
Major rice	Harvested area	56,972	57,652	57,774	57,542	57,442	0.14
	Production	23,142	22,650	23,539	22,840	23,387	0.30
	Yield	406	393	407	397	407	0.15
Second rice	Harvested area	9,533	9,432	8,914	9,903	10,074	1.60
	Production	6,426	6,332	5,888	6,753	6,802	1.80
	Yield	674	671	661	682	675	0.19
Maize	Harvested area	6,943	7,040	6,626	6,040	5,970	-4.45
	Production	4,178	4,216	3,943	3,716	3,602	-4.14
	Yield	602	599	595	615	603	0.30
Soybean	Harvested area	961	945	929	886	873	-2.52
	Production	231	218	226	215	214	-1.64
	Yield	240	230	243	242	245	0.93
Cassava	Harvested area	6,386	6,608	6,162	6,693	7,339	2.95
	Production	19,718	21,440	16,938	22,584	26,916	6.98
	Yield	3,087	3,244	2,749	3,375	3,668	3.92
Sugarcane	Harvested area	7,121	7,012	6,670	6,033	6,314	-3.83
	Production	74,259	64,996	49,586	47,658	64,365	-5.79
	Yield	10,429	9,269	7,434	7,899	10,194	-2.03
Oil palm	Harvested area	1,799	1,932	2,026	2,374	2,663	10.41
	Production	4,903	5,182	5,003	6,715	6,613	8.96
	Yield	2,725	2,682	2,469	2,828	2,483	-1.32
Rubber	Harvested area	10,008	10,354	10,574	10,870	11,017	2.44
	Production	2,861	3,008	2,977	3,071	3,122	1.97
	Yield	286	290	282	282	283	-0.49
Longan	Harvested area	619	680	821	870	939	11.38
	Production	396	597	712	472	495	3.58
	Yield	596	878	655	542	528	-6.99
Durian	Harvested area	733	748	717	701	680	-2.16
	Production	739	831	651	623	723	-3.26
	Yield	1,007	1,110	908	889	1,063	-1.13
Pineapples	Harvested area	509	556	614	632	597	4.59
	Production	1,899	2,101	2,183	2,705	2,305	6.61
	Yield	3,573	3,513	3,557	4,280	3,858	3.57

Units: Harvested area in thousand rais, Production in thousand tonnes, and Yield in kilograms per rai

Source: Office of Agricultural Economics (2009)

Livestock production in Thailand has its origins in the semi-domesticated stock of subsistence production systems. Thai livestock production is a modernised industry providing hygienic animal products to the world market (Falvey, 2000). Thai livestock production faced a huge revolution starting in the 1970s after the Charoen Pokphand Company (CP) was established as a commercial exporter of broiler chicken to Japan. The successful and rapid growth of the broiler export-oriented industry led several large companies to enter into livestock business and the livestock contract farming has become a common practice among Thai farmers (Delgado, Narrod, & Tiongco, 2008).

Delgado et al. (2008) identified three major types of livestock contract farming in Thailand. They include: (i) guaranteed price in baht per kilogram; (ii) wage contract with the hiring rate in baht per kilogram; and (iii) wage contract with the hiring rate in baht per head. Guaranteed price contract was the popular contract in the Thai livestock industry. Livestock contract farming can be seen not only in poultry farms but also in swine farms throughout Thailand. The contract terms and regulations may differ for each farm depending on farm location and the agreement between the commercial livestock company and the farmer.

The expansion of livestock contract farms is concentrated in a small number of provinces around Bangkok. The reason is the proximity of major feed industrial areas, the largest meat market and the main export ports and shipping services. The most important production zones of broiler and swine contract farming include Nakorn Pathom and Ayudhaya in the central area, Chonburi and Chacherngsao in the east, and Nakorn Rachasima in the north-east (Delgado et al., 2008).

Conversely, the development of the dairy industry in Thailand is under the government management conducted by the Dairy Farming Promotion Organization of Thailand. The major components of the dairy industry, such as breeding stock imports, production subsidies, tariff barriers and quota protection, have directly involved the Thai government to help small-scale dairy farmers and dairy producer cooperatives to increase their competitiveness (Delgado et al., 2008). Falsey (2000) suggested that future enhancement of the Thai dairy industry depends on the stock survival and reproductive rates, feed quality including concentrate and roughage feed, genetics, and farmers' management skills.

Chudam and Toros (2008) argued that most dairy farms in Thailand are small holder dairying. The average number of milking cows per farm has risen from 8.41 milking cows per farm in 1993 to 18.66 milking cows per farm in 2006. Delgado et al. (2008) identified the three most important provinces for dairy farms as Ratchaburi in the west, Saraburi in the central region and Nakorn Ratchasima in the north-east.

Table 2.13 shows the major livestock population numbers and the number of livestock farms in Thailand as of 1 January 2007. Most commercial livestock farming, such as poultry, swine, and dairy cows, is significantly concentrated in the central region. Cattle and buffaloes are the most important livestock for smallholder farmers in the north-east (Department of Livestock Development [DLD], 2008).

Table 2.13 Number of livestock inventory on 1 January 2007 and number of livestock farms in Thailand by region, 2007

Livestock	*Items*	*North*	*North-east*	*Central*	*South*
Buffalo	Number of heads	225,970	1,175,826	129,866	46,136
	Number of farms	31,009	326,563	12,836	7,408
Cattle	Number of heads	1,953,406	4,501,769	1,516,298	876,919
	Number of farms	168,482	908,673	101,895	197,072
Pig	Number of heads	1,780,029	1,693,707	53,038,136	788,201
	Number of farms	112,367	95,465	25,401	35,122
Dairy cows	Number of heads	42,918	101,942	339,795	4,938
	Number of farms	1,912	4,112	14,965	241
Broiler	Number of birds	16,466,308	32,478,230	113,745,460	7,610,979
	Number of farms	11,172	21,486	6,558	9,309
Layer	Number of birds	5,837,855	9,418,102	28,372,204	5,808,854
	Number of farms	2,319	8,582	3,900	2,597

Source: Department of Livestock Development (2008)

Farm production in Thailand is either crop specialized or integrated crop-livestock. According to Roonnaphai (2005), the promotion of crop diversification and integrated farming systems has been widely debated among Thailand agricultural policy makers since the 8th National Economic and Social Development plan (1997-2001). The purposes of this policy are to create stability between agricultural production and the use of natural resources, improve the standard of living of farmers and also to reduce risk and uncertainty on farms. However, Wattanachariya and Jitsanguan (1992) argued that smallholder farmers in rural rain-fed areas of Thailand are not able to expand their farm activities because of limited farm size, lower farm management skills, lack of capital and credit and the inadequate use of farm inputs.

Poapongsakorn et al. (2006) identified nearly 65 per cent of total farms in the central region as specialized crop production farms, around 20 per cent as integrated crop and livestock farms and the rest as pure livestock farms, such as poultry and swine farms. In contrast, 48 per cent are integrated crop and livestock farms in the north-east region. The major livestock activities include cattle, buffaloes, or milking cows. The proportion of specialized crop farms in this region is estimated at about 45 per cent and 5 per cent are mixed crop-livestock-freshwater fish production farms.

Following the 1997 Asian financial crisis, the King of Thailand, His Majesty King Bhumibol Adulyadej, suggested the concept of “Sufficient Economy” to the public. The Thai government has incorporated this concept into the economic development policy that aims to overcome poverty, improve the rural livelihood, and lead Thailand to sustainable economic development (The Government Public Relations Department [PRD], 2004).

At the same time, his Majesty's "New Theory" concept is to guide particularly smallholder farmers to achieve self-sufficiency. There are three stages in the New Theory of agricultural management process (PRD, 2008):

- First, farmers will produce adequate food for their household consumption by maximizing efficient land utilization management. Any production surplus may be sold on the market.

- Secondly, farmers will organise themselves to establish farmer cooperatives to conduct various activities focussing on production, such as input bargaining, sharing of farm machinery, and selling negotiation. In this stage, the group of farmers can help each other to increase bargaining power, resulting in cost reduction and increased in product prices and management of group production planning.

- Thirdly, the farmer cooperatives will enlarge their commercial activities, such as owning rice-mills. This stage will strengthen the group of farmers and the farmers can learn production, processing and marketing.

In terms of land use management, the strategy recommended that smallholder farmers separate their farm land into four parts. The proportions of 30:30:30:10 restructured land forms were suggested to maximize farm income. This type of farming system has been well researched and developed to suit Thailand's agriculture. First, around 30 per cent of farm land would be constructed into a reservoir to provide adequate water for the farm during the dry season and freshwater fish production for additional income. The next 30 per cent is rice plantation to service farm household consumption, any surplus can be sold. Thirdly, commercial field crops were encouraged to be grown in another 30 per cent of the farm land. Finally, the last 10 per cent was for farm residence, animal sheds and storage (PRD, 2008).

The New Theory concept has been successfully implemented. Many Thai smallholder farmers who applied this strategy found that it was useful and adaptable. The New Theory brought back the integrated crop-livestock farming system to supply small farm household consumption and produce higher farm incomes. This strategy also helped to improve the living standard and strengthen the farmers' group participation (Falvey, 2000; Thaiprasert, 2006). The New Theory is one of the most important agricultural production development policies in the 10th National Economic and Social Development plan (2007-2011) (MOAC, 2008).

2.4 Sources of risk and risk management strategies on farm

There is much literature on risk sources that impact farming operations and their risk management strategies. Flaten, Lien, Koesling, Valle and Ebbesvik (2005) argued that the assessment of farmers' perceptions and how they respond to risk are very important because this can describe the decision making behaviour of farmers when faced with risky situations. Similarly, Hardaker, Huirne et al. (2004, p. 12) stated that *"the welfare of the farm family and the survival of farm business may depend on how well farming risks are managed"*.

The lack of relevant information on farmers' risk perceptions and their risk behaviour present a challenging task for policy makers and researchers who want to create a proper risk management system to help farmers (Flaten et al., 2005; Nicol, Ortmann, & Ferrer, 2007). According to empirical studies, there is no agreement about the most appropriate methods to describe sources of risk and risk responses on farms. However, the Likert-scale rating method has been regularly applied in previous research. In most of those studies, the respondents were asked to rate the sources of risk that affected their farm and the risk management strategies they used on a five-point scale (where 1 is not particularly important and 5 is highly important).

The types of on-farm risk can be divided into two main categories: business risk (which directly affects farm profitability) and financial risk (which is associated with the variability of net cash flows to farmers' equity) (see Section 1.1). Pellegrino (1999) argued that both business and financial risk can affect each other and need to be considered carefully when developing a whole farm plan. Nicol et al. (2007) argued that the sources of farm risk, especially business risk, may vary depending on farm type, farm size, the economic situation, political environment, time of the study and farm geographical location. The sources of farm risk are summarised in Table 2.14.

Boggess, Anaman, and Hanson (1985) examined farmers' awareness of risk in crop and livestock production in northern Florida and southern Alabama. A total of 48 farmers were randomly selected. The respondents were requested to identify the definition of risk and then to rank the sources of risk and risk management strategies based on how important each risk was to their farm. The results showed that most respondents defined risk as the probability of a negative outcome. The respondents ranked rainfall variability, pests and diseases, and crop price variability as the primary sources of risk for crop production. Livestock price and weather variability and livestock diseases were perceived as important sources of risk for livestock production.

Patrick, Wilson, Barry, Boggess and Young (1985) studied farmer attitudes towards risk and risk management among mixed crop and livestock farmers in the US. A total of 149 farmers in 12 states were interviewed. The respondents were grouped into five farm types; mixed farming; cotton; corn, soybean and hogs; small grain and ranch. The results showed that changes in weather, output price and input costs were rated as the three most important sources of risk in both crop and livestock production.

In Martin's (1996) study, a nationwide mail survey was used to examine the sources of risk and the risk management strategies of New Zealand farmers. The survey covered eight farm types including sheep and beef, dairy, deer, pip fruit, kiwifruit, cropping, vegetables and flowers. The results showed that marketing risk (such as change in product prices and change in input costs) was ranked as a very important source of risk by all farmers. Conversely, production risks (such as rainfall variability, weather, and pests and diseases) were regarded differently depending on geographical location, farm type and product.

Pellegrino (1999) studied rice farmers' perceptions of the sources of risk and risk management responses in Argentina. Using size of the respondents' farms as large, medium, and small farms, the author argued that a farmer's awareness of the sources of risk varied depending on farm size. The small size farm group tended to have a higher awareness of production risks than the other two groups.

Meuwissen, Huirne and Hardaker (2001) identified price and production risks as the most important sources of risk for livestock farmers in the Netherlands. An insurance scheme was rated as the appropriate strategy to manage risk. Flaten et al. (2005) compared risk perception and the risk responses of conventional and organic dairy farmers in Norway. The results demonstrated that the institutional (such as government support policies) and marketing risks were classified as the principal sources of risk for the organic dairy farmers. The authors ranked production cost variability and animal welfare policy as the greatest worries for conventional dairy farmers.

Hall, Knight, Coble, Baquet and Patrick (2003) found severe drought and meat price variability as the primary sources of risk perceived amongst cattle farmers in Texas and Nebraska. In a recent study, large-scale South African sugarcane farmers perceived land reform regulations, labour legislation and crop price variability as the three most important risk factors (Nicol et al., 2007).

Table 2.14 Ranking perception of potential risk factors on farms in worldwide studies

Risk source variables	*Boggess et al. (1985)*	*Patrick et al. (1985)*	*Martin (1996)*	*Pelligrino (1999)*	*Meuwissen et al. (2001)*	*Flaten et al. (2005)*	*Hall et al. (2003)*	*Nicol et al. (2007)*
Studies location	US	US	New Zealand	Argentina	Netherlands	Norway	US	South Africa
Type of farm	Crop	Livestock	Sheep & Beef	Rice	Livestock	Dairy	Cattle	Sugarcane
Crop yield variability	-	-	-	-	-	-	-	5
Crop price variability	3	-	-	6	-	-	-	3
Livestock production variability	-	-	-	-	6	-	-	-
Livestock price variability	-	1	1	-	1	2	2	-
Rainfall variability (severe drought)	1	-	5	2	-	-	1	-
Other weather factors	-	3	10	3	-	-	5	-
Pests and diseases	2	4	9	8	1	5	6	-
Production cost variability	6	2	2	12	5	3	3	4
Government law and policies	5	9	7	9	7	1	4	1
World economic situation	8	7	2	-	-	-	-	-
Nation economic situation	-	-	2	1	-	-	-	-
Hired labour force	11	12	11	10	-	8	7	2
Variability in interest rates	9	8	8	7	4	6	-	7
Credit availability	13	10	-	-	-	9	-	8
Changes in Inflation/deflation rate	4	6	-	-	-	-	-	-
Farmer operator safety and health	7	5	5	13	2	4	-	6
Theft of farm equipment	10	-	12	14	-	-	-	-
Changes in technology	12	11	13	11	8	7	-	-

Note: The numbers in this table represent the ranking of sources of risk in each study, 1 as the most important sources of risk and the last number as the least important sources of risk.

In terms of risk management strategies, Boggess et al. (1985) and Patrick et al. (1985) reported that ‘placing of investments’, ‘obtaining market information’ and ‘enterprise diversification’ were the most important strategies that the sampled crop and livestock farmers use to handle risk in the US. Meuwissen et al.(2001) found that ‘cost of production’ and ‘insurance schemes’ were regarded as important risk strategies among livestock farmers in the Netherlands. Similarly, Flaten et al. (2005) noted that organic and conventional dairy farmers in Norway perceived ‘increasing farm liquidity’, ‘disease prevention’, ‘buying farm insurance’ and ‘cost of production’ as the most important strategies used to deal with risk on their farms.

Martin (1996) stated that New Zealand farmers used a mix of risk management strategies to reduce risk. The strategies varied among the groups of farmers depending on the nature of the product, market structure and conditions, farmer characteristics, dynamic risk adjustment considerations and the regulatory situation. The risk management strategies are summarized in Table 2.15.

Despite the fact that the evaluation of farmers’ risk perceptions and risk management responses are essential to better understand their risk behaviour and managerial decisions, few studies have explicitly investigated awareness of risk among Thai farmers. Kukeawkasem (2008) studied sources of risk and risk management strategies among 408 swine farmers in northern Thailand. Multiple and logit regressions were employed to examine the relationship between farmers’ risk attitudes and sources of risk and socio-economic characteristics of the farmers. The author’s results showed that ‘animal diseases’ and ‘capability to manage a pig farm’ were the most important sources of risk that significantly impacted swine farmers’ risk attitudes. In addition, ‘reducing input uses’, ‘cost flexibility’, ‘holding reserve’, ‘insurance’ and ‘diversification’ were considered as the most important risk management strategies among swine farmers in the study area.

Akasinha, Ngamsomsuk, Thongngam, Sinchaikul and Ngamsomsuk (2006) examined risk perceptions among rice farmers in Payao and Lampang provinces in the northern region. In this study, the Participatory Risk Mapping (PRM) technique was used to elicit sources of risk. The authors’ results showed that rice farmers in Payao faced five major sources of risk including ‘outbreak of rice disease’, ‘insects causing damage to rice’, ‘high input costs’, ‘flooding’, and ‘shortage of water supply’. Farmers in Lampang typically faced ‘drought’, ‘insects causing damage to rice’, ‘low output prices’, ‘pests’, and ‘high input costs’.

Table 2.15 Ranking perception of potential farm risk management strategies in worldwide studies

Risk management strategies	*Boggess et al. (1985)*	*Patrick et al. (1985)*	*Martin (1996)*	*Pelligrino (1999)*	*Meuwissen et al. (2001)*	*Flaten et al. (2005)*	*Hall et al. (2003)*
Studies location	US	US	New Zealand	Argentina	Netherlands	Norway	US
Type of farm	Crop & Livestock	Crop & Livestock	Sheep & Beef	Rice	Livestock	Dairy	Cattle
Enterprise diversification	1	3	6	12	7	8	6
Market information	3	2	3	6	-	-	-
Cooperative marketing	-	-	-	-	-	6	-
Spreading sales	7	4	3	1	-	9	-
Forward contracting	10	9	17	6	5	10	7
Use of futures market	17	17	-	-	8	-	8
Pacing of investment	2	1	16	11	6	13	5
Debt management	13	11	11	4	4	5	-
Maintaining financial reserves	4	5	9	2	-	1	3
Holding credit reserves	16	8	14	13	-	-	4
Managed capital spending	14	14	6	-	-	7	-
Keeping debt low	-	-	3	8	-	-	-
Use of insurance	8	12	9	4	2	3	-
Farm operator working off-farm	15	15	19	14	-	11	-
Family members working off-farm	11	16	18	-	-	11	-
Maintaining feed reserves	6	6	1	-	-	-	-
Production practice diversification	5	7	12	-	-	-	-
Routine spraying and drenching	-	-	1	-	-	-	-
Monitor pests and diseases	-	-	15	3	-	2	1
Not produce to full capacity	12	13	12	-	-	1	-
Producing at lowest possible costs	-	-	-	-	1	4	2
Incentives and rewards for labour	-	-	-	8	-	-	-
Apply strict hygienic rules	-	-	-	-	3	-	-
Maintaining flexibility in farm	9	10	6	10	-	-	-

Note: The numbers in this table represent the ranking of risk management strategies in each study, 1 as the most important risk management strategies and the last number as the least important risk management strategies.

The PRM is a systematic and convenient technique to apply to categorize and order sources of risk. Smith, Barrett and Box (2000) employed the PRM technique to study risk perceptions among pastoralists in the arid and semi-arid land of southern Ethiopia and northern Kenya. Their results showed there were many differences among ethnic groups and other general characteristics among pastoralists. One hundred and twenty respondents were interviewed and 15 major sources of risk were identified. The most frequent risk factors identified for pastoralists include food shortages, water availability and livestock diseases. These results were from drought and long dry seasons in East Africa. A similar study by Quinn, Huby, Kiwasila and Lovett (2003) focused on the local perceptions of risk in Tanzania. The authors' results showed the respondents grouped risks into 21 categories. Access to the water supply was the risk most frequently cited by respondents. The sources of risk cited by male and female respondents differed slightly depending on their experience. The authors also suggested that the PRM is a useful technique for realizing sources of risk that affect a group of people in rural areas.

Barrett (2003) pointed out that the PRM technique is a qualitative-quantitative method of integration. This method used an open-ended questionnaire for collecting sources of risk where the respondents identified and ranked the risks concern to them. Following this, a simple index can be constructed using the ordinal data. The author also argued that the data can be analyzed using limited dependent methods. In addition, The World Bank (2007) suggested that the PRM method can illustrate the sources and levels of risk faced by a group of people. This is an especially useful method to pre-identify the types of risk in areas that have limited studies on risk. However, the PRM technique has some constraints (K. Smith et al., 2000). For example, the meaning of risk differs and may be unclear among the respondents and may cause misleading answers. The categorization of responses is difficult due to ambiguous answers and because some answers are possibly influenced by the interviewers.

Chapter 3
Literature Review

This chapter presents some theoretical concepts for evaluating and ranking on-farm risky alternatives. The conceptualization of the expected utility theory is described in the first section. The next section presents the concepts of risk aversion. The technique to elicit the decision makers' utility function and the utility functional forms are discussed in Sections 3.3 and 3.4 respectively. Section 3.5 concludes with the fundamental concepts of risk efficiency approaches and previous studies on agricultural decision making under risk using the stochastic efficiency.

3.1 Expected utility theory

The expected utility theory plays a principal role in measuring a person's preferences under complex decision situations. The mathematical form of the expected utility was initiated by Gabriel Creamer and Daniel Bernoulli in the eighteenth century (Anderson, Dillon, & Hardaker, 1977; Schoemaker, 1980). That was later recognized as the St Petersburg paradox. The fair coins game was demonstrated in this paradox following the conditions that the coin is tossed till the nth toss when the first head arises, then an individual wins the prize of 2^{n-1} dollars. What certain amount would an individual be willing to pay to play this game? The expected prize of the game can be infinite as follows:

$$\sum_{n=1}^{\infty} \frac{1}{2^n} 2^{n-1} = \infty \qquad (3.1)$$

Where:

$\frac{1}{2^n}$ is the probability of the occurrence; and

n can be any number from 1 to infinity.

According to Levy (2006), the amount which the player is willing to pay is the "certainty equivalent" (CE) of the game. This kind of game is similar to a risky investment. For instance, say one is willing to pay 50 dollars to play this game. Then, in the game, tails shows up four times with a head once. The prize of this game is $2^{5-1} = 2^4 = 16$ dollars, which means one loses 34 dollars; and the probability of the occurrence is $\frac{1}{2^5} = \frac{1}{32}$. Initially, the expected prize of the game is infinite but, in the real world, this paradox is difficult to explain how people feel about lotteries using mathematical expression.

In general, people try to maximize their expected payoff but are willing to pay a comparatively small amount of money (finite) to play a game (Levy, 2006; McKenna, 1986). Bernoulli assumed that people, in making their decisions, prefer those alternatives that maximize their expected utilities (utility depends on wealth) rather than expected monetary values (Bassett, 1987; Levy, 2006; Schumann, 2005). In addition, each person has a different perception of the value of the lottery because the utility of an extra dollar is different between a rich man and a poor man. This illustrates that a person's utility related to wealth increases at a decreasing rate.

Bernoulli used a logarithmic function as a plausible expected utility function to describe his proposal (Bassett, 1987; Schoemaker, 1980). Bernoulli's utility function is expressed as follows:

$$U(x) = b\left[\log\frac{\alpha + x}{\alpha}\right] \tag{3.2}$$

Where:

b is a constant;

α is the initial wealth; and

x is the increase in wealth (Schoemaker, 1980).

Bernoulli's concept of expected utility has been repeatedly reviewed as a riskless theory in consumer economics in many studies during the second half of the nineteenth century (Fishburn, 1988). However, in 1947, John von Neumann and Oskar Morgenstern developed a new theory of utility known as the economic theory of games. The theory represents rational decision-making under stochastic outcomes in the form of axioms of preference (Schoemaker, 1980).

According to the Von Neumann and Morgenstern theory, a person ought to constantly prefer an alternative with the highest expected utility (Schoemaker, 1980; Schumann, 2005). The axioms about the attributes of an individual's preference over a simple lottery (a lottery with just two alternatives) are expressed as follows (Schoemaker, 1980):

1. The complete ordering axiom: For any lottery, there is an ordering, which is complete and transitive. For every L_1 and L_2, the individual prefers either L_1 to L_2 (we can write $L_1 \succ L_2$) or L_2 to L_1 ($L_2 \succ L_1$) or else is indifferent ($L_1 = L_2$). Moreover, for every L_1, L_2 and L_3 with $L_1 \succ L_2$ and $L_2 \succ L_3$ then $L_1 \succ L_3$ (called transitivity).

2. The continuity axiom: If an individual prefers outcomes x to y and y to z then there exists a subjective probability p (between 0 and 1). This means that the

individual is indifferent between a sure amount of y and a lottery offering x with probability p or a lottery offering z with probability $(1-p)$.

3. The independence axiom: Let L_1 and L_2 be two lotteries with $L_1 \succ L_2$; L_3 is any other risky prospect and $\alpha \in (0,1)$ then $\alpha L_1 + (1-\alpha)L_3 \succ \alpha L_2 + (1-\alpha)L_3$.

4. The unequal probability axiom: If outcome x is preferred to y, then lottery L_1 should be preferred to L_2 when both lotteries have the only outcomes x and y and when the probability of winning x is higher in L_1 than L_2.

5. The axiom of complexity: Let L_1 and L_2 be two lotteries, offer outcomes x and y for L_1 and create two new lotteries L_3 and L_4 as the outcomes for L_2. Lottery L_3 and L_4 have only outcomes x and y. The individual should be indifferent between L_1 and L_2 only if the expected values of L_1 and L_2 are equal.

The Von Neumann and Morgenstern expected utility concept can explain the relationship of an individual's preferences over the probability of the real outcomes throughout the functional forms. However, the measurability controversy has been widely discussed among economists during the 1950s in terms of *"ordinal"* and *"cardinal"* utility (Mongin, 1997; Pennings & Garcia, 2004). A number of Neoclassic economists agree that for a given individual's preferences, the ordinal properties of $U(a)$ can be provided by using a non-stochastic theory of preferences among the outcomes (Mongin, 1997). However, in 1987 Maurice Allais noted that the appropriate technique to analyse choice under risky prospects required both a function of wealth under certainty by using a cardinal specification and a separate attitude toward uncertainty (Quiggin, 2002). Pennings and Garcia (2004, p. 6) summarised that *"ordinary utility provides only a ranking of risky prospects while cardinal utility refers to a decision maker's strength-of-preference function for consequences under certainty"*.

Therefore, the expected utility theorem says that a person's utility function (U) exhibits his/her preferences for consequences are congruent with the above axiomatic properties. The function correlates a single utility value ($U(a_j)$) with any risky prospect (a_j) and has the following properties (Anderson et al., 1977; Hardaker, Huirne, et al., 2004):

1. If a_1 is preferred to a_2, then $U(a_1) > U(a_2)$ and vice versa. That is the *"utility value can be used to rank risky prospects and to identify the one with the highest utility as the most preferred"* (Hardaker, Huirne, et al., 2004, p. 35).

2. The preference relation in terms of the expectation of some utility function based on the decision maker’s subjective distribution of outcomes. In other words, *“the utility of a risky prospect is its expected utility value”* (Hardaker, Huirne, et al., 2004, p. 35). This can be defined by the following equation:

$$U(a_j) = E\left[U(a_j)\right] \tag{3.3}$$

In the case of discrete outcomes, equation (3.3) becomes:

$$U(a_j) = \sum_i U(a_j\theta_i)P(\theta_i) \tag{3.4}$$

Where:

θ_i is an uncertain event; and

$P(\theta_i)$ is the probability of the incidence of an uncertain event θ_i.

and, in the case of continuous distributions of outcomes, is given as:

$$U(a_j) = \int U(a_j\theta) f(\theta) d\theta \tag{3.5}$$

Hardaker, Huirne et al. (2004, p. 36) state that *“the implication in both equations (3.4) and (3.5) is that higher order moments of utility such as variance do not enter into decisions among risky prospects”*.

3. This U function is *“unique up to a positive linear transformation”* (Hardaker, Huirne, et al., 2004, p. 36).

3.2 Risk aversion

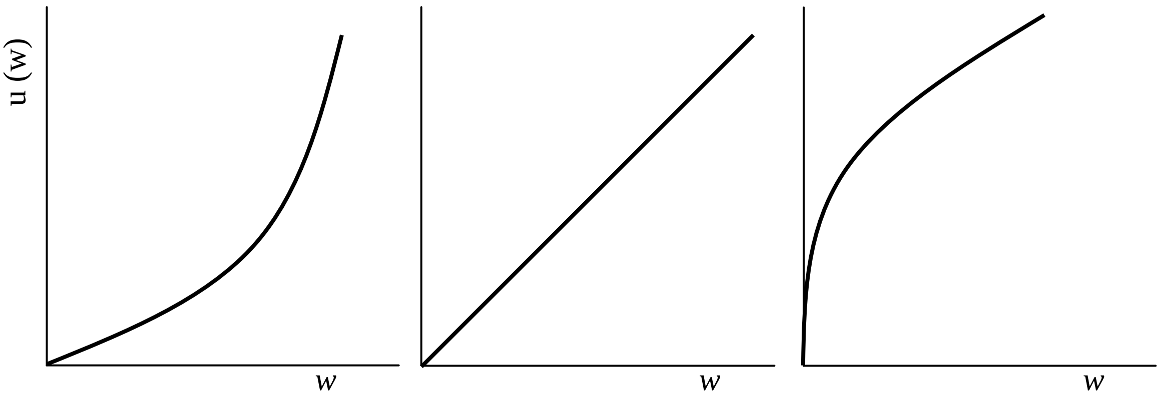
Risk aversion is the central behavioural concept in the expected utility theory (Quiggin, 1993, 2002). Risk aversion measures a decision maker’s unwillingness to accept a bargain with an uncertainty payoff rather than another bargain with more certainty but with the probability of a lower expected payoff. This implies that the shape of a decision maker’s utility function reflects his or her risk preferences (Hardaker, Huirne, et al., 2004). The decision maker’s utility function has a positive slope over the whole range of payoffs, which implies that greater payoff is always preferred to less. This can be illustrated in mathematical terms as $U'(w) > 0$, where $U'(w)$ is the first derivative of the utility function with respect to wealth (Hardaker, Huirne, et al., 2004).

Risk aversion can be measured by the second derivative of the utility function for wealth ($U''(w)$). In other words, risk aversion is the change in the marginal utility as the level of wealth increases. This became a way to classify a decision maker’s attitude toward risk as risk loving, neutral or averse in terms of the second derivative (Hardaker, Huirne, et al., 2004; Schumann, 2005):

1. $U''(w) > 0$ means risk averse;
2. $U''(w) = 0$ means risk neutral; and
3. $U''(w) < 0$ means risk loving.

The three possible attitudes to risk classification are shown in Figure 3.1.

Figure 3.1 The shape of utility functions exhibiting risk attitude behaviour with respect to wealth (w)



(a) Risk Preference (b) Risk Neutral (c) Risk Averse

Source: Hardaker, Huirne et al. (2004)

Because the utility function is defined only up to a positive linear transformation and can be measured on an ordinal scale, the value of U'' is of little relevance and difficult to use to compare risk aversion (Binici, Koc, Zulauf, & Bayaner, 2003; Quiggin, 1993). The coefficient of absolute risk aversion, developed by Pratt (1964) and Arrow (1965), is the best way to elicit risk attitudes by using a measure that is invariant and constant for any positive linear transformation of a utility function (Hardaker, Huirne, et al., 2004). The Arrow-Pratt measure of absolute risk aversion can be expressed as:

$$r_a(w) = \frac{-U''(w)}{U'(w)} \tag{3.6}$$

Where:

$r_a(w)$ is the coefficient of absolute risk aversion; and

$U''(w)$ and $U'(w)$ are the second and first derivatives of the utility function, respectively.

Hardaker, Huirne et al. (2004) stated that the coefficient of absolute risk aversion function can be classified in relation to how it changes with respect to increasing wealth (w). Schumann (2005) argued that the absolute amount of change can be calculated by using the derivative with respect to wealth of the absolute risk aversion coefficient ($r_a'(w)$). The three categories are:

1) Decreasing absolute risk aversion (DARA) arises if $r_a'(w) < 0$. This implies that the more the decision maker's wealth increases, the constant amount of money that he/she is willing to pay in the risky prospects increases (Levy, 2006; Schumann, 2005).

2) Constant absolute risk aversion (CARA) arises if $r_a'(w) = 0$. Hardaker, Huirne et al. (2004) argues whether a constant amount of money is added to or deducted from all payoffs in the risky prospect, the decision maker's preferences are still the same.

3) Increasing absolute risk aversion (IARA) arises if $r_a'(w) > 0$. IARA implies that the decision maker's willingness to pay for the risky outcomes decreases as his/her wealth increases (Schumann, 2005).

The measurement of $r_a(w)$ relies on the monetary units of w , which means different currency units are not comparable for risk aversion. To overcome this restriction, Pratt and Arrow introduced the coefficient of relative risk aversion ($r_r(w)$), which is autonomous of w levels (Hardaker, Huirne, et al., 2004; Quiggin, 1993). The relative risk aversion coefficients can be calculated as follows:

$$r_r(w) = -wr_a(w) \tag{3.7}$$

Similarly, the relative risk aversion function can be categorized as decreasing relative risk aversion (DRRA), constant relative risk aversion (CRRA) or increasing relative risk aversion (IRRA). Using the derivative with respect to w of $r_r(w)$ ($r_r'(w)$) shows the changes in the proportional amounts of money that the decision maker is willing to pay with risky prospects. DRRA arises if $r_r'(w) < 0$ and, as a decision maker's wealth increases, the proportional amount of money that he/she is willing to pay with risky prospects increases. Similarly, CRRA and IRRA arises if $r_r'(w) = 0$ and $r_r'(w) > 0$ respectively (Hardaker, Huirne, et al., 2004; Schumann, 2005).

3.3 Utility elicitation

Several methods have been developed to extract a decision maker's preferences for wealth and convert their preferences into an appropriate utility function (McConnell & Dillon, 1997). Three common widely used methods are reported in the literature to represent farmers' attitudes and their utilities toward risk. They include (Gómez-Limón, Arriaza, & Riesgo, 2003):

1) Direct elicitation of the utility functions (DEU): In this method, the farmer's risk preferences are assessed by interview. The farmer is asked to state their indifference point with a series of the hypothetical risky prospects and the sure outcomes. An individual utility function can be calculated using regression. According to Young (1979) and Gómez-Limón et al. (2003), some empirical research that used DEU to elicit the risk preferences of farmers can be found in Francisco and Anderson (1972), Hamal and Anderson (1982), Ramaratnam, Rister, Bessler and Novak (1986) and Feinerman and Finkelshtain (1996).

2) Experimental methods (EM): Real money payoffs are employed to measure farmers' preferences rather than using hypothetical alternatives. However, this approach is not widely used and is quite complicated to implement in practice (Gómez-Limón et al., 2003). Binswanger (1980) employed the EM technique to measure the attitude toward risk of rural farm households in India. The results of his study showed that all respondents were moderately risk-averse. Also, the author argued that the EM is a reliable technique compared with DEU because the interviewer's bias can influence the DEU results.

3) Observed economic behaviour (OEB): In this method, the risk response behaviour of farmers can be estimated from econometric models that incorporate risk attitude parameters along with other observed parameters. OEB is less costly compared with the DEU and EM techniques and researchers can generate risk effects econometrically from a large amount of response data. However, the OEB approach has some restrictions because of the availability of aggregate data and other relevant economic variables that might influence risk attitudes (Gómez-Limón et al., 2003; Rovere, 1997; Young, 1979). Studies that used the OEB method to estimate farmers' attitudes toward risk include Chavas and Holt (1990), Chavas and Holt (1996), Pope and Just (1991) and Lence (2000).

Anderson et al. (1977) argued that the most reliable method to elicit a decision maker's preferences is to require him or her to choose between two-state risky choices with equal probability of 0.5 for each state and the sure prospect until indifference is achieved. Some decision makers experience an uncomplicated assessment to choose but others find it difficult.

Therefore, Anderson et al. (1977) introduced two elicitation techniques to obtain the certainty equivalent (CE) with unbiased probability. A CE is the sure amount of payoff that a decision maker would have to accept and to be indifferent between receiving the amount of payoff and taking the given risky choices (Anderson et al., 1977; McConnell & Dillon, 1997). Furthermore, Anderson et al. (1977) and Hardaker, Huirne et al. (2004) emphasized that a decision maker's risk behaviour can be evaluated using the information from CE. The expected money value (EMV) can be employed to compare with the CE to identify a decision maker's risk behaviour. The decision maker can be classified as risk averse if CE is smaller than EMV. Conversely, if EMV is larger than CE the decision maker is classified as risk loving. Moreover, the difference between the mean or EMV of a risky prospect and its CE ($EMV - CE$) is called the "risk premium" (McConnell & Dillon, 1997).

The two utility elicitation techniques developed by Anderson et al. (1977) are: (a) the equally likely certainty equivalent (ELCE) method and (b) the equally likely risky outcome (ELRO) method. The details of these two techniques are discussed below.

The equally likely certainty equivalent (ELCE) method

The ELCE is the most common and efficient method used to elicit individual utility functions (Binici et al., 2003; Torkamani & Haji-Rahimi, 2001). The ELCE method begins with a simple hypothetical lottery of 0.5/0.5 probabilities, which include the best and worst possible outcomes of the decision problem presented to the decision maker (Anderson et al., 1977). The decision maker is asked for a sure prospect (CE) that he or she would accept to make him/her indifferent between the sure sum and a risky prospect. The CEs are produced for each lottery question and are used to plot the individual utility function. The upper and lower boundaries of the utility function are set at good and bad possible attribute levels (Ananda & Herath, 2005).

According to Hardaker, Huirne et al. (2004), shorthand notations are established in order to explain details of the elicited procedure. We denote ($a_1, a_2, ...$) as a decision maker's judgments with a set of possible payoffs with corresponding probabilities. We can write the risky decisions ($a_1, a_2, ...$) with a discrete payoffs and the sure one (a_s) as follows:

$$(X_1, X_2, ...; p_1, p_2, ...) \sim (X_s; 1.0) \tag{3.8}$$

Where:

$X_1, X_2, ...$ is a set of possible payoffs;

$p_1, p_2, ...$ is the probability, summing to 1.0; and

the ~ symbol implies "is indifferent between".

The process of elicitation of CEs for the ELCE method can be explained as follows (the notations a, b, c, d, e, f specify different values of the payoff to assess w) (Hardaker, Huirne, et al., 2004; Ladányi, 2008):

Step 1 → set a scale by assuming that a is the lowest payoff of interest and b is the highest. We declare that $U(a) = 0$ and $U(b) = 1$.

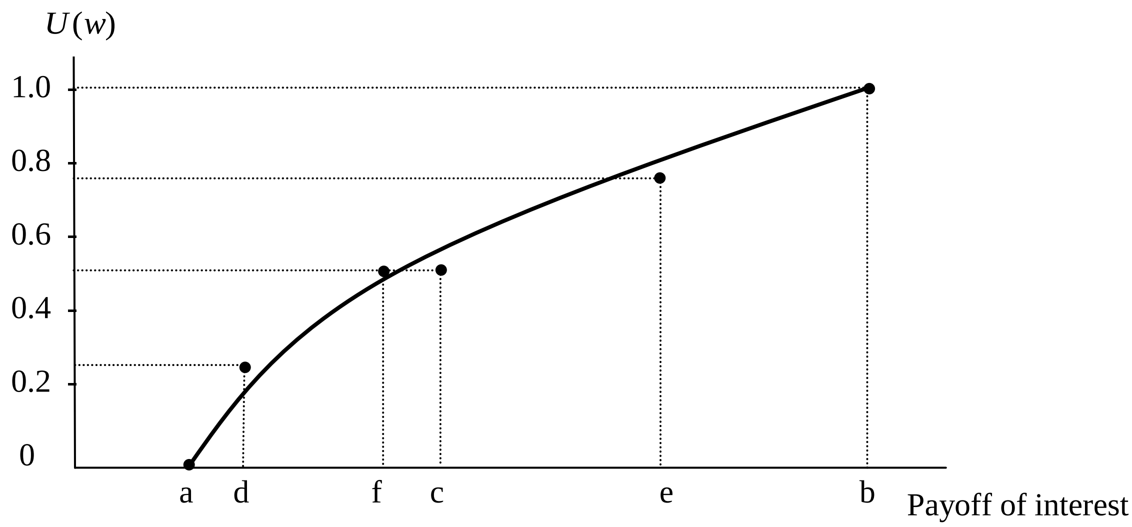
Step 2 → estimate c such that $(a, b; 0.5, 0.5) \sim (\text{c}; 1.0)$. Next, we can calculate $U(c)$ by $U(c) = 0.5U(a) + 0.5U(b) = 0.5$.

Steps 3-4 → estimate d and e using $(a, c; 0.5, 0.5) \sim (\text{d}; 1.0)$ and $(c, b; 0.5, 0.5) \sim (\text{e}; 1.0)$. We obtain $U(d) = 0.5U(a) + 0.5U(c) = 0.25$ and $U(e) = 0.5U(d) + 0.5U(b) = 0.75$.

Step 5 (for the optional check) → estimate f such that $(d, e; 0.5, 0.5) \sim (\text{f}; 1.0)$. Then we obtain $U(f) = 0.5U(d) + 0.5U(e) = 0.5$.

Those CE values (a, b, c, d, e, f) that correlate with the utility values of 0 to 1 are used to construct a utility function graph (see Figure 3.2).

Figure 3.2 Utility function derived from the ELCE elicitation method



Source: Ladányi (2008)

The equally likely risky outcome (ELRO) method

The ELCE and ELRO methods are quite similar. Quiggin (1981) pointed out that the ELRO method compared the risky decision using pairs of values elicited from the same probabilities but with different outcomes. Anderson et al. (1977) argued that the ELRO presents the utility function for outcomes over the range a to z, $a < z$, can be formally expressed in the general form as follows (Hardaker, Huirne, et al., 2004):

$$(a, d; 0.5, 0.5) \sim (\text{b,c;0.5,0.5}) \tag{3.9}$$

This method starts by picking a reference interval outcome with $a < b$ and $c > a$ then is asked for d that makes the decision maker indifferent among the risky prospects. To set the scale for the utility function, it is assumed that $U(b) - U(c) = 1$ and $U(a) = 0$ is defined as the origin. Hence, $U(d) = 1$. In the following step, replace the outcome c with d to discover a new indifference (defined as e), which refers to as a new point of utility value. The procedure continues until a whole range of utility points is captured. The utility function is plotted as in the ELCE method (Hardaker, Huirne, et al., 2004).

The ELCE method has been widely used and recommended for utility function evaluations, especially from farmers, because it more reliable and less complicated compared with the ELRO. The ELCE is an unbiased method since it is based on the equal probability of 50:50 risky prospects. Hardaker, Huirne et al. (2004, p. 98) stated that *"most people find 50:50 risky prospects much easier to conceptualize than prospects with other probability ratios"*. In previous studies, survey questionnaires and interview techniques have been incorporated in the ELCE method to elicit the CE for a series of risky outcomes to use as a utility value.

For example, Tauer (1986) conducted a study using the ELCE method to assess risk preferences among dairy farmers in New York. The author attempts to explain the effect of risk preferences on farming decisions. Seventy two respondents were interviewed; the results showed that 34 per cent were risk averse, 39 per cent were risk neutral, and the rest were risk loving. However, there is limited evidence to reveal the relationship between farmers' risk preferences and their actions and on-farm decisions. Oglethorpe (1995) employed the ELCE to derive utility values for a sample of 20 farmers in northern England. The author examined how the farm plan developed under the profit maximization approach. The author used a negative exponential utility function to fit the values with non-linear least squares. The Arrow-Pratt coefficients of absolute risk aversion were estimated and the MOTAD programming model employed to generate the E-V frontiers. The results illustrated that, under the profit maximisation approach, risk-averse farmers are extremely sensitive in their decision making when the expected farm income declined slightly.

Torkamani (2005) evaluated the risk aversion attitudes of farmers in Fars province, Iran. A total of 60 respondents were interviewed using an applied ELCE questionnaire to elicit the farmers' utility values and the absolute risk aversion coefficients were assessed. The results showed that all sampled farmers were risk averse. The empirical range of the absolute risk aversion values ranged from 0.0001 to 0.000001.

Ananda and Herath (2005) conducted a study of community risk preferences of forest land-use in Australia using multi-attribute utility theory. The ELCE method was used to extract the individual utility functions. There was significant risk-averse behaviour among stakeholders of the old-growth forest, conservation and forest-based recreation groups. However, there was less risk-averse behaviour in the native timber extraction group.

According to the literature, the ELCE method has been employed as the basic instruments for generalization of the individual utility function. However, Hardaker, Huirne et al. (2004) identified some constraints of the ELCE method. First, the ELCE method requires the decision maker to compare between a risky prospect and a sure outcome. If the person avoids gambling or is a gambling lover then biased decisions may occur. Particularly if the decision maker is a person who believes that gambling is prohibited by religion, the ELCE may not apply at all. When this occurs, the ELRO is the alternative method to elicit the individual utility function. Secondly, both the ELCE and ELRO may be used to compare only in the continuous outcomes, such as wealth or income, but cannot apply to discrete outcomes.

3.4 Utility functional forms

The utility function determines an individual's relative preferences with respect to different levels of wealth (Norstad, 1999). The function can be transformed in terms of algebraic form for computing and making comparison among its properties. The different algebraic specifications of the utility function may affect the classification of risk preferences of the decision maker in different ways (Anderson et al., 1977; Hardaker, Huirne, et al., 2004).

A number of functional forms have been used in previous research to illustrate farmers' attitudes toward risk. Lin and Chang (1978) investigated the most appropriate functional forms to assess farmers' utility function. The results showed that the logarithmic and semi-logarithmic were the appropriate functional forms that can best describe decreasing absolute risk aversion. The authors suggested that the choice of utility functional forms can affect the classification of risk preference results. Buccola and French (1978) reported risk parameter estimation problems using the exponential utility form. Their results showed that logarithmic transformation of the exponential utility function was inconsistent with the Von Neumann and Morgenstern principles. The use of the Box-Cox transformation and power functional forms were inappropriate to estimate the utility function because of intercept problems (Buccola, 1982).

Musser et al. (1984) emphasized the problems when using different functional forms to classify the risk attitude of a decision maker. The authors applied the quadratic, semi-log and modified power functional forms to categorize risk preferences of 13 graduate students in an agricultural finance class during winter 1981. Their results showed that the quadratic and modified power function categorized most respondents as risk neutral whereas all the respondents were risk-averse using the semi-log function form. The authors argued that alternative utility functions may affect classification of risk preferences.

Ramaratnam, Rister, Bessler and Novak (1986) examined the appropriateness among the four different utility functional forms (quadratic, log-linear, semi-log and exponential) to describe the risk behaviour of grain sorghum farmers in Texas. The exponential function was determined as the most appropriate functional form to explain farmers' risk preferences. Zuhair, Taylor and Kramer (1992) indicated that the exponential form was appropriate when employed to explain risk aversion and the prediction of farmers' harvesting strategy in Sri Lanka. Both studies argued that the choice of utility functional forms is very important because different utility functional forms can describe farmers' risk preferences in different ways.

Saha (1993) introduced a new utility functional form namely the expo-power utility function. The author emphasized that the expo-power utility function is flexible to demonstrate almost any type of risk aversion coefficient structure (DARA, CARA, IARA, DRRA or IRRA) that is devoid of restriction relying on parameter values. Saha, Shumway and Talpaz (1994) employed the expo-power utility function and production function using the joint estimation method to describe the risk preference structure and production technology among Kansas wheat farmers. The risk characteristics of farmers in their study exhibited DARA and IRRA. The authors argued that the joint estimation method was suitable when applied to estimate production parameters with utility function parameters.

Torkamani and Haji-Rahimi (2001) used four different utility functional forms to test goodness of fit and compared their properties. The authors' results showed that all the sampled farmers were risk averse when the exponential and expo-power utility functions were used. On the other hand, 65 per cent and 75 per cent of the farmers were categorized as having risk averse behaviour using the cubic and quadratic utility function, respectively. Similarly, a study of 50 farmers from Turkey found that 49 and 48 farmers were classified as risk-averse for the expo-power and the power utility function, respectively. Fifteen of the 50 farmers were risk loving when the cubic utility function was tested. All of the interviewed farmers were risk-averse when the negative exponential utility function was used (Binici et al., 2003). Ananda and Herath (2005) argued that the negative exponential functional form was popularly employed to produce the utility function in previous studies on multi-attribute conditions.

The most appropriate functional forms and type of risk measurement that are recommended to specify utility function are listed below (Binici et al., 2003; Hardaker, Huirne, et al., 2004; Torkamani & Haji-Rahimi, 2001):

1. The cubic utility function

   The cubic utility functional form can be expressed as:

$$U(w) = a + bw + cw^2 + dw^3 \tag{3.10}$$

Where:

$U(w)$ is the utility with respect to wealth (w); a, b, c and d are parameters.

The cubic utility function can examine the Arrow-Pratt absolute risk aversion coefficient ($r_a(w)$) as follows:

$$r_a(w) = \frac{-U''(w)}{U'(w)} = -\left[\frac{(2c + 6dw)}{(b + 2cw + 3dw^2)}\right] \tag{3.11}$$

Binici et al. (2003) and Torkamani and Haji-Rahimi (2001) pointed out that $r_a(w)$ of the cubic utility function can be either negative or positive depending on the parameter values and level of wealth. The cubic utility function is compatible with risk aversion, risk neutrality and risk loving behaviour because it exhibits both IARA and DARA.

2. The negative exponential utility function

   The negative exponential utility function can be formally expressed as:

$$U(w) = 1 - \exp(-cw), c > 0 \tag{3.12}$$

Where:

exp denotes exponential; c is parameter.

The absolute risk aversion coefficient of the negative exponential utility function estimated as follows:

$$r_a(w) = \frac{-U''(w)}{U'(w)} = c \tag{3.13}$$

The vital properties of this utility function are that $r_a(w)$ is constant (c) and positive over all levels of wealth (Binici et al., 2003; Ladányi & Erdélyi, 2007). Hence, the negative exponential utility function assumes CARA and is extensively used in empirical decision analysis because the function itself can be assessed using a single CE with a normal distribution of wealth. However, Hardaker, Huirne et al. (2004) argued that it may have some numerical problems when assessing the negative exponential utility function for large values of wealth together with a relatively large values of c.

3. The power utility function

The power utility functional form can be written as:

$$U(w) = \alpha + \beta w^{\gamma}, 0 < \gamma < 1 \tag{3.14}$$

Where:

α, β and γ are parameters.

The absolute risk aversion coefficient of the power utility functional form can be calculated as follows:

$$r_a(w) = \frac{-U''(w)}{U'(w)} = -(\gamma - 1)w^{-1} \tag{3.15}$$

The power utility function has interesting properties because it exhibits DARA, which decreases while wealth increases and the $r_a(w)$ is positive (Binici et al., 2003).

4. The expo-power utility function

The expo-power utility functional form can be expressed as:

$$U(w) = \gamma - \exp(-\beta w^{\alpha}), \gamma > 1, \alpha \neq 0, \beta \neq 0, \alpha\beta > 0 \tag{3.16}$$

Where:

α, β and γ are parameters.

The absolute risk aversion coefficient of the expo-power utility functional form can be calculated as follows:

$$r_a(w) = \frac{-U''(w)}{U'(w)} = \frac{(1 - \alpha + \alpha\beta w^{\alpha})}{w} \tag{3.17}$$

According to Saha (1993), the attractive property of the expo-power utility function is its flexibility and that it can exhibit IARA if $\alpha > 1$, CARA if $\alpha = 1$ and DARA if $\alpha < 1$. Moreover, this functional form is quasi concave for all values of $w > 0$.

However, there are other common functional forms that could be used to describe the risk behaviour of the farmers such as log, exponent and a hyperbolic absolute risk aversion (HARA) type utility function (Schumann, Richardson, Lien, & Hardaker, 2004).

3.5 Risk efficiency approaches

As discussed above, to evaluate risky alternatives requires consideration of the whole range of outcomes with their probability distributions, along with the relative preferences (utilities) of the decision maker(s) for those consequences.

The efficiency criteria approach should be applied when decision analysis is based on uncertain situations and the preferences of the decision makers are unknown (Lien, Stordal, et al., 2007). Efficiency criteria allow some ranking of risky choices when the specific utility is not provided (Hardaker, Huirne, et al., 2004). Three common methods are used for ranking risky alternatives including mean variance (E-V), stochastic dominance and certainty equivalent (CE) when simulation is employed (Lau, 2004). The mean-variance efficiency method is widely used in whole-farm planning but this technique does not incorporate a decision maker's risk preferences (Hardaker, Huirne, et al., 2004; Hardaker, Richardson, et al., 2004; Lau, 2004).

Stochastic dominance (SD) is one of the most widely used risk efficiency approaches to rank risky alternatives. The SD technique relies on a pair-wise comparison of alternative risky prospects (Hardaker, Huirne, et al., 2004). Each alternative is enclosed with the probability distribution of outcome x that is described by a cumulative distribution function (CDF). The CDF, denoted by $F(x)$, is given as:

$$F(x) = P(X \le x) = \sum_{X \le x} P(x) \qquad \text{for a discrete distribution; and} \qquad (3.18)$$

$$F(x) = \int_{-\infty}^{x} f(t)dt \qquad \text{for a continuous random variable.} \qquad (3.19)$$

Where:

X is a random variable; and

x is a particular value, $F(x)$ ranges from $F(-\infty) = 0$ to $F(+\infty) = 1$ (Levy, 2006).

Some stochastic dominance decision analysis forms are briefly introduced below. The development of each technique involves the wellness of fit in risk preferences assumptions and a reduction in the size of the efficient set (Hardaker, Huirne, et al., 2004).

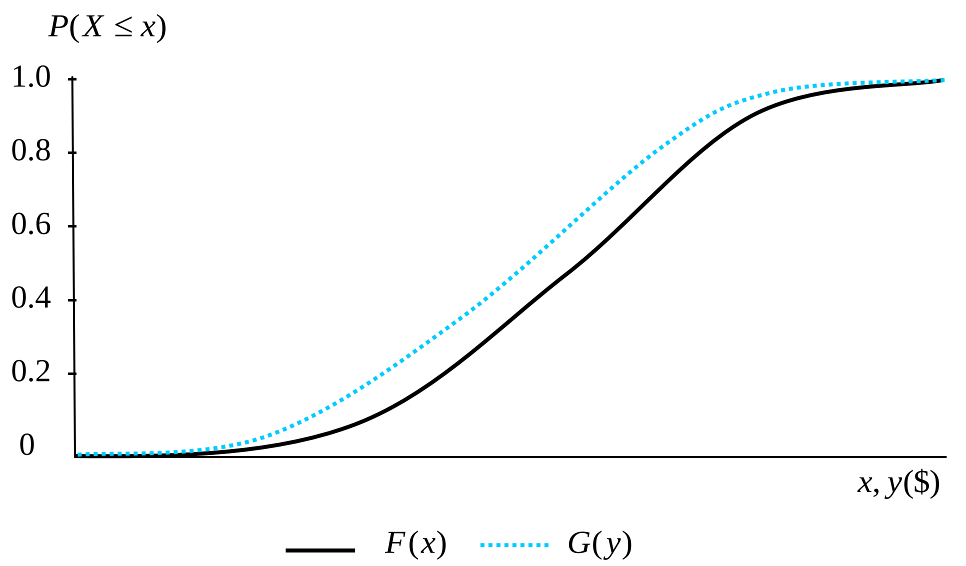
<u>First-degree stochastic dominance (FSD)</u>

The FSD is the most uncomplicated form of stochastic dominance. This technique is used to rank the alternatives for the individual who prefers more wealth to less, implying that $U' > 0$ (Hardaker, Huirne, et al., 2004; Levy, 2006). Let us assume that the decision maker is faced with two alternative plans X and Y, and desires to rank the two risky plans that have the CDF of $F(\cdot)$ and $G(\cdot)$, respectively. The FSD rule can tell us whether one alternative stochastically dominates the other or we can say the alternative X is first degree stochastically dominant over Y if and only if:

$$F(x) \leq G(x) \quad \text{, for all } x \tag{3.20}$$

with at least one strong inequality (Schumann, 2005). This implies that the CDF of X lies below and to the right of the CDF of Y. If the CDFs of X and Y crosses each other, then neither dominates. Therefore, this is a crucial point to the limited discriminatory power of the FSD (Hardaker, Huirne, et al., 2004). See Figure 3.3 for a graphical representation of the FSD analysis.

Figure 3.3 First-degree stochastic dominance analysis applied to two of alternative plans, X and Y



Note: It can be clearly seen that X is first degree stochastically dominant over Y.

Source: Schumann (2005)

Second-degree stochastic dominance (SSD)

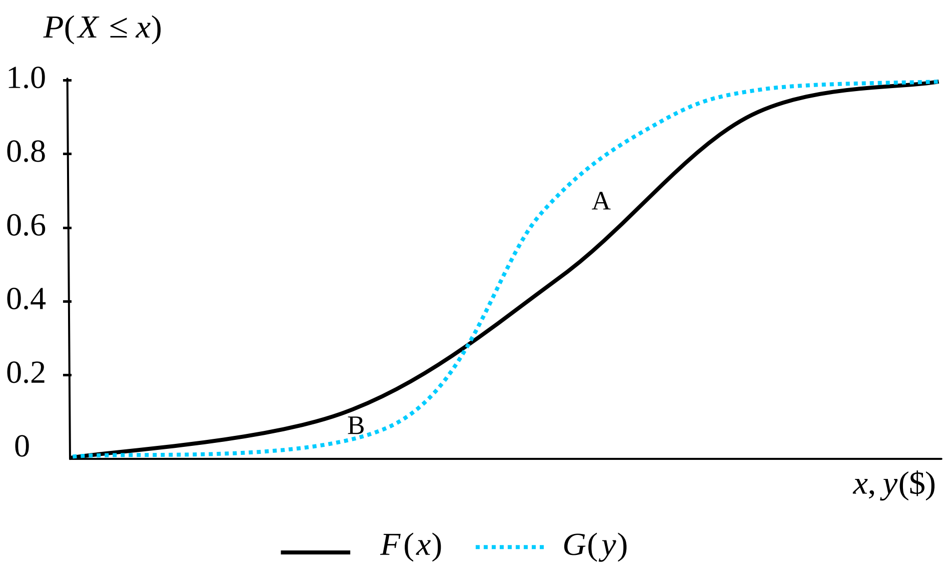
This is designed to rank two risky alternatives X and Y with related distribution functions $F(\cdot)$ and $G(\cdot)$ under the SSD criterion. The restrictive axiom required is that most decision makers are risk averse, preferring more wealth to less from which it may be inferred that the utility function is concave or $U' > 0$ and $U'' < 0$. The risk aversion coefficient bounds are $0 \le r_a(w) \le +\infty$ (Hardaker, Huirne, et al., 2004). Alternatively, X is said to be second degree stochastically dominant over Y if, and only if:

$$\int_{-\infty}^{x} [G(t) - F(t)]dt \ge 0 \quad \text{, for all values of } x \tag{3.21}$$

with at least one strong inequality (Schumann, 2005). In the SSD, the distribution of outcomes is indicated by the area under the CDF curve of each alternative. Graphically, this says that *"the curve of the cumulative area under the CDF for the dominant alternative lies everywhere below and to the right of the corresponding curve for the dominated alternative"* (Hardaker, Huirne, et al., 2004, p. 149). See Figure 3.4 for an illustration of the SSD analysis.

Hardaker, Huirne et al. (2004) and Lien, Stordal et al. (2007) argued that the SSD is more discriminatory than the FSD. However, the SSD test cannot yield useful results from previous studies because the efficient sets are still too large.

Figure 3.4 Second-degree stochastic dominance analysis applied to two alternative plans, X and Y



Note: Alternative X is second degree stochastically dominant over alternative Y because area A is greater than area B.

Source: Schumann (2005)

Stochastic dominance with respect to a function (SDRF)

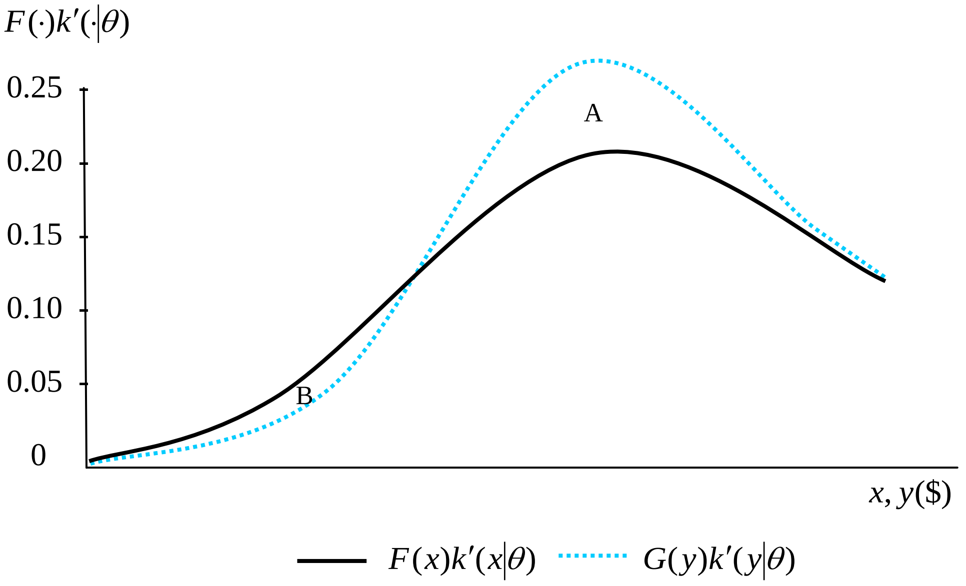
The SDRF, which is also called generalized stochastic dominance, is an alternative to SSD and FSD because it has more discriminatory power than both methods. The SDRF requires the appropriate assessment of the decision makers' utility functional forms to be fitted in its computation process. Evidently, the different applications of a utility function can affect the results of this technique. SDRF allocates a ranking to risky alternatives for decision makers whose absolute risk aversion coefficient lies within set boundaries, upper ($r_U(w)$) and lower ($r_L(w)$) bound, $r_L(w) \le r_a(w) \le r_U(w)$ (Hardaker, Richardson, et al., 2004).

For example, assume there are two risky alternatives X and Y with associated cumulative distributions $F(\cdot)$ and $G(\cdot)$, respectively. Alternative X is said to be second degree stochastically dominant over Y with respect to function $k(x)$ if, and only if:

$$\int_0^y \left[G(x) - F(x)\right] dk(x) \ge 0 \,, \forall y \in [0,1] \qquad (3.22)$$

See Figure 3.5 for a graphical representation of the second degree stochastic dominance with respect to a function analysis.

Figure 3.5 The utility-weighted distribution function of two alternative plans, X and Y



Note: In this case, alternative X is second degree stochastically dominant over alternative Y with respect to the negative exponential utility function $k(x|\theta) = \delta - e^{-\theta x}$ and $\theta = r_a = 0.010$ or as it can be seen from the graph, alternative X dominates Y because area A is greater than area B.

Source: Schumann (2005)

Stochastic efficiency with respect to a function (SERF)

Hardaker, Huirne et al. (2004) introduced SERF, a new method for ranking risky alternatives. The authors argued that there are more advantages in SERF over SDRF. SERF varies risk aversion over a defined range and ranks risky alternatives in terms of CE of each alternative over the relevant parameter of the utility function (Schumann, 2005). SERF can be applied with any utility function and can identify a smaller efficient set for a specified degree of risk aversion which can be parameterised within a given upper and lower bound than SDRF (Hardaker & Lien, 2010). SERF can compare any level of decision makers' preferences including risk-averse, risk neutral and risk loving. In addition, SDRF requires a pair-wise comparison between two risky alternatives to investigate which alternative is stochastically dominant over the other but SERF can compare all risky alternatives over the defined range of absolute risk aversion (Meyer, Richardson, & Schumann, 2009).

Hardaker, Huirne et al. (2004, p. 154) state that *"for each risky alternative and for a chosen form of the utility function, the subjective expected utility hypothesis means that utility can be calculated depending on the degree of risk aversion (r) and the distribution of wealth (w)"* as follows:

$$U(w,r) = \int U(w,r) f(w) dw \qquad (3.23)$$

Where:

U is the utility function and the expression is calculated for selected values of r over the range r_L (lower) to r_U (upper).

The CE for each of these values of U is defined as follows:

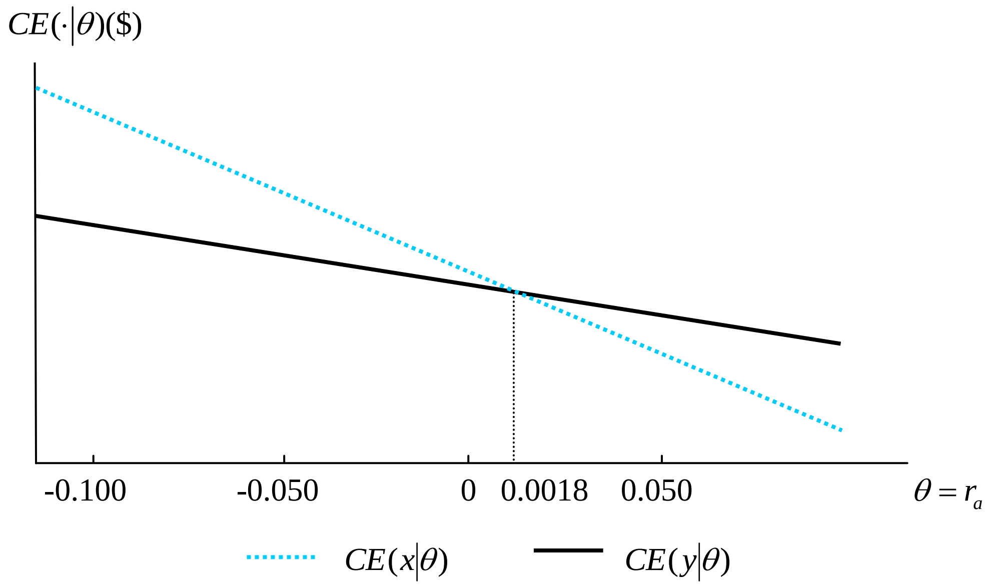
$$CE(w,r) = U^{-1}(w,r) \qquad (3.24)$$

The rule of SERF is "*the efficient set contains only those alternatives that have the highest (or equal highest) CE for some value of r_a in the relevant range"* (Hardaker, Huirne, et al., 2004, p. 154). An illustration of the SERF methods of evaluating two risky alternatives is given in Figure 3.6.

With SERF analysis, the range of risk aversion to be used is very important (Lien, Stordal, et al., 2007). Anderson and Dillon (1992) recommended a rough classification of the degree of risk aversion coefficient ranging from 0.5 for a decision maker who is least risk averse to 4.0 for a decision maker who is extremely risk averse.

The SERF technique is a novel improved methodology for assessing and ranking risky alternatives but empirical studies using SERF are limited. In this study, the technique is applied to assess a set of alternative risky farming systems. The SERF method ranks alternative risky farming systems in terms of the CE of annual net farm revenue over a range of risk aversion levels.

Figure 3.6 Stochastic efficiency with respect to a function analysis, showing the certainty equivalent (CE) for two alternative plans, X and Y



Note: In this case, alternative X presents stochastic efficiency over Y with respect to the negative exponential utility function $k(w|\theta) = \delta - e^{-\theta w}$ over a range of values of $\theta \in (-\infty, 0.018)$ and alternative Y presents stochastic efficiency over X over a range of values of $\theta \in (0.018, \infty)$.

Source: Schumann (2005)

According to the literature, the economic risk efficiency using stochastic approaches to investigate risk efficient alternatives in agriculture is well researched. Stochastic approaches are applied to compare risky alternatives in farm production, marketing and financial matters (see Table 3.1). The important findings of those studies are summarized and discussed below.

Risky farm production alternatives

In terms of on-farm production, stochastic approaches have been used to quantify and compare risk efficiency among the different farm production alternatives. Lien et al. (2006) applied SERF to assess and compare the distribution of net farm returns between three risky cropping systems including organic, integrated and conventional farming systems in eastern Norway. Their results showed that an organic cropping system was the most efficient alternative and appropriate for risk-averse farmers in the area. Lien, Hardaker and Flaten (2007) applied a whole-farm stochastic model to support eastern Norway farmers' decision making whether to change from conventional farming systems to organic. Their model assessed the financial performance of both farming systems. Six years planning the net present value (NPV) distribution for each farm system were generated under two scenarios: the current scenario and the reducing organic price premiums scenario. SERF was used to investigate the alternative risky farming systems for each scenario. The scenario results showed that when the farmers tried to eliminate organic areas payments and organic price premiums from the stochastic model, the conventional system was higher economically and more risk efficient compared with the organic farming system.

Tzouramani, Karanikolas, Alexopoulos, Sintori and Liontakis (2008) examined the net return of sheep production in the Macedonia region of Greece. SERF was employed to determine risk efficiency between conventional and organic sheep farming. The data obtained from eight conventional and 16 organic sheep farms were combined with the historical data of yield and price from 1999 to 2003. The results showed that both conventional and organic sheep farming exhibited a low possibility to generate a negative net return and the organic method was stochastically efficient over the conventional sheep farming. However, the authors found that, when the organic subsidies were removed, conventional sheep farming was more risk efficient than organic farming. Like Tzouramani, Karanikolas and Alexopoulos's (2008) study, the authors found that the organic subsidies and crop loss assistance payments were important factors to help the organic cultivation of lemons and citrus be more economically viable than conventional cultivation.

Upadhyay, Smith, Clayton and Harker (2004) investigated net returns associated with risk for canola production in Alberta. Canola farmers were confronted by some risky alternatives including cultivar selection, time of seeding and time of weed control. Eighteen different management decisions in canola production were examined to evaluate their net returns and risks. The results showed that seeding in early spring with late weed control was the risk efficient production alternative for risk-averse Alberta canola farmers. Devkota, Holcomb, Taylor and Epplin (2006) applied SERF to rank the most risk efficient cropping pattern for farmers in Oklahoma. The stochastic simulation model was employed to examine the net return distribution for the eight different cropping alternatives. The results showed that seedless watermelon production was stochastically more efficient than other cropping alternatives and appropriate for the risk loving farmers, but irrigated peanut production was economically viable for risk averse farmers.

In Weisensel and Schoney's (1989) study, the authors examined the risk efficiency of incorporating lentils with wheat in Saskatchewan farms. Two crop rotations were selected as sample alternatives for the farmers. The authors applied SDRF to establish the suitable risk aversion levels of farmers who needed to incorporate lentils with their wheat system. The authors' results indicated that lentil rotation would be preferred by risk loving farmers, but a wheat rotation was suitable for risk averse farmers. The authors also argued that the farmers' risk attitude was the main criterion why many farmers in Saskatchewan would not incorporate lentils in the wheat rotation. Similarly, McLellan and Carlberg (2010) investigated the most risk efficient crop rotations for southern Manitoba for grain and oilseed farmers to integrate legumes and legume cover crops into their farm production. The results showed that including a black lentil cover crop into a cereal based production system was stochastically efficient over the other crop rotation alternatives and appropriate for the risk neutral and all levels of risk averse farmers. This crop rotation not only increased the farmers' net returns by approximately 49 per cent but could also reduce the application of chemical fertilizer.

Lien, Stordal et al. (2007) conducted a study to investigate an optimal tree replanting plan on an area recently harvested in Norway. The NPV distribution of each rotation plan length from t = 60 to 110 years was calculated. SERF illustrated that the forest owner's degree of risk aversion affected both the optimal rotation plan selection and the reinvestment decision. The results showed that the shorter rotation length would be preferred by risk-neutral forest owners. The authors argued that policy makers should incorporate the forest owners' degree of risk aversion to implement a suitable policy on forest investment.

Pendell, Williams, Boyles, Rice and Nelson (2007) conducted a study to examine the net returns in Kansas corn production using the no-tillage system versus conventional tillage with either commercial nitrogen or cattle manure. Eight production systems were constructed to simulate the net farm returns using either conventional tillage or no-tillage with either ammonium nitrate or cattle manure on corn farms. The SERF results showed that no-tillage with cattle manure was stochastically efficient over other production systems and suitable for risk neutral and less risk averse farmers. The results also indicated that this production system could raise the level of carbon in the soil but gave lower net returns. The authors argued that carbon credits or government programme incentives were not required to attract risk-averse corn farmers to use no-tillage. Yiridoe, Weersink, Hooker, Vyn and Swanton (2000) applied SDRF to assess and compare the net returns associated with risk for one conventional tillage and seven conservation tillage practices (including five reduced tillage and two no tillage) in corn and soybean cropping systems for two clay soils in Ontario. The tillage system selection was crucial in soil conservation. Total net returns were calculated for each of the eight tillage systems. The results showed that the conventional tillage systems dominated the reduced tillage and no-tillage systems in both clay soil types regardless of levels of risk aversion.

Archer and Reicosky (2009) investigated the most risk efficient tillage system alternatives on corn and soybean production in west-central Minnesota. Eight different tillage systems were constructed to compare their risk efficiency using SERF analysis. Historical yield data for each tillage system (1997-2003) were obtained from the experimental farm. Crop and input prices for 2003 to 2007 were collected from the Census of Agriculture and all prices were adjusted to 2007 dollars. The results showed that fall residue management was the most economically viable alternative and appropriate for risk neutral and risk averse corn and soybean producers.

Shively (1999) conducted a study to analyse risk and profitability associated with soil preservation of hedgerows practice among hillside corn farms in the Philippines. This practice was widely recommended to hillside farmers because it can increase soil fertility and decrease the use of chemical fertilizers. The author used SDRF combined with a heteroskedastic regression model to investigate the hypothesis that the hedgerow practice could lower yield risk. The average data on yields and NPV were compared using data collected from a sample of 115 hillside corn farms in the province of Davao del Sur. The regression results showed weak support for the hypothesis that hedgerow practice could reduce yield variability. However, the SDRF results showed that such a practice was appropriate for the farmer who had a coefficient of relative risk aversion in the range of 3.0-5.5.

Risky marketing alternatives

Elrod, Robinson and Richardson (2008) applied SERF to investigate the most risk efficient marketing strategy that would be preferred by the risk averse cotton farmers in west Texas. Three marketing alternatives were constructed to evaluate their performance in terms of reducing price risk. They were forward pricing, cash selling at harvest and putting the crop into a Commodity Credit Corporation loan programme to delay selling. The authors employed scenario analysis to investigate each marketing strategy for both irrigated and dry land cotton farms. The findings showed that in every scenario the put option was the most risk efficient marketing strategy and appropriate for the risk averse irrigated and dry land cotton farmers.

Donnelly and Noel (2006) evaluated the optimal forward contracting strategy for lettuce farmers in California. The authors employed five different market combinations: 40 per cent contract-60 per cent cash market, 50 per cent contract-50 per cent cash market, 65 per cent contract-35 per cent cash market, 80 per cent contract-20 per cent cash market and 100 per cent contract, to quantify which option generated the highest economic returns and was risk efficient for the lettuce farmers. The results indicated that 100 per cent contract was the stochastically efficient option and would be preferred by all levels of risk averse lettuce farmers. However, the authors suggested that a 100 per cent contract strategy might be impossible in the real world. This was because there are not enough buyers available in the market and some farmers are willing to sell their products in the cash market. Therefore, combinations of 65 per cent, or more, contract should be possible options to generate higher returns for the farmers.

Risky financial alternatives

Lau (2004) conducted a study to investigate the effect of economic factors on the location decision and the financial feasibility project of MixAlco, a corn-based ethanol factory, in three alternative regions in Texas. The author employed SERF to simulate the 16-year planning NPV distribution to predict the optimal location preference for decision makers with different levels of risk aversion. The results showed that, compared with other alternative locations, the central region was preferred by risk-averse decision makers. The author also argued that SERF was a useful technique for analysing feasibility and location problems.

Richardson, Herbst, Duncan, den Besten and van Hoven (2007) investigated and compared the economic returns associated with risk between Dutch dairy farms and dairy farms in different regions of the US. The authors tried to elucidate whether Dutch dairy farmers should continue their farm operations in the Netherlands or relocate their investments to the US. The 10-year NPV of net returns (2002-2011) was simulated for each dairy farm and SERF was employed to rank the NPV distributions with different levels of farmers' risk preferences. The results showed that risk averse Dutch dairy farmers who had sufficient equity preferred to liquidate their farm operations in the Netherlands and emigrate to the US to invest in dairying in Idaho or north Texas. This is because the dairy farms in these areas were stochastically efficient over dairy farms in other regions of the US.

Nartea and Webster (2008) attempted to clarify whether New Zealand sheep and beef farmers could earn some benefits by incorporating other financial investments, such as ordinary industrial shares, government bonds and bank bills, to diversify their farm asset portfolios.

Mean-variance (EV) analysis was employed to generate the possible risk efficient portfolio options using historical annual rates of return on farmland, shares, bonds and bank bills from 1990 to 2005. Each portfolio option was simulated using different combinations of investment strategies, which can represent different risk-return characteristics, ranging from the minimum variance portfolio to the maximum expected return portfolio. The authors employed SERF to rank the portfolio options' CE over a range of farmers' risk preferences. The results indicated that investing in financial assets was preferred by New Zealand farmers who had a high degree of risk aversion, but incorporating bonds rather than shares for portfolios was appropriate for somewhat risk averse farmers.

Table 3.1 Summary of the economic risk efficiency in agriculture studies using stochastic approaches

Author(s)	*Country/Area of the studies*	*Major purpose(s)*	*Stochastic approaches*	*Results of the study*
Farm production alternatives – compare organic versus conventional farming systems				
Lien et al. (2006)	Norway	Evaluate risk efficiency of organic, integrated and conventional crop farming systems.	SERF	• Organic farming is risk efficient over the other farming systems and most suitable for all risk averse farmers.
Lien, Hardaker et al. (2007)	Norway	Investigate economic sustainability and risk efficiency between organic and conventional crop farming systems.	SERF	• The economic sustainability of conventional farming tends to be higher than organic farming, especially when the organic areas payments and organic price premiums were removed.
Tzouramani et al. (2008)	Greece	Evaluate risk efficiency of organic versus conventional sheep farming.	SERF	• Organic sheep farming generates higher expected net farm income than conventional sheep farming. This is because of the effect of the organic subsidies.
Tzouramani, Karanikolas and Alexopoulos (2008)	Greece	Determine risk efficiency between organic and conventional lemons and citrus cultivation.	SERF	• Organic lemons and citrus farming are stochastically efficient over the conventional farming and appropriate for all risk averse farmers.
Farm production alternatives – determine the most risk efficient farming alternatives				
Upadhyay et al. (2004)	Alberta, Canada	Investigate the most risk efficient cropping alternatives for canola production.	SDRF	• Seeding in early spring with late weed control was the most economically viable canola production option and appropriate for risk averse farmers.

Table 3.1 Summary of the economic risk efficiency in agriculture studies using stochastic approaches (cont.)

Author(s)	*Country/Area of the studies*	*Major purpose(s)*	*Stochastic approaches*	*Results of the study*
Devkota et al. (2006)	Oklahoma, USA	Determine and compare economic risk cropping patterns for farmers.	SERF	• Seedless watermelon production was the most suitable cropping option for risk loving farmers, while the irrigated peanuts production was suitable for risk averse farmers.
Weisensel and Schoney (1989)	Saskatchewan, Canada	Assess the net returns associated with risk between wheat and lentil crop rotations.	SDRF	• Wheat rotation would be preferred by the risk averse farmers and lentil rotation was appropriate for risk loving farmers.
McLellan and Carlberg (2010)	Manitoba, Canada	Investigate the economic risk crop rotations which incorporate legumes and legume cover crops into cereal production.	SERF	• Including black lentil cover crop in cereal production was the most economically viable for the risk neutral and all levels of risk averse farmers.
Lien, Stordal et al. (2007)	Norway	Investigate the most risk efficient tree replanting strategies.	SERF	• Shorter rotation length preferred by the risk neutral forest owner.
		Farm production alternatives – determine the most risk efficient tillage systems		
Pendell et al. (2007)	Kansas, USA	Investigate the risk efficient system alternatives between no-tillage and conventional tillage systems of corn production.	SERF	• No-tillage and cattle manure was the most risk efficient production system and appropriate for risk neutral and less risk averse corn producers.

Table 3.1 Summary of the economic risk efficiency in agriculture studies using stochastic approaches (cont.)

Author(s)	*Country/Area of the studies*	*Major purpose(s)*	*Stochastic approaches*	*Results of the study*
Yiridoe et al. (2000)	Ontario, Canada	Compare net returns for conventional tillage and conservation tillage systems of corn and soybean production on two types of clay soil.	SDRF	• Conventional tillage systems were generally considered more efficient in reducing risk than other systems for both types of clay soil.
Archer and Reicosky (2009)	Minnesota, USA	Assess the economic risks and net returns for different tillage system options for corn-soybean production.	SERF	• Fall residue management was stochastically efficient over the other tillage system options and appropriate for the risk neutral and risk averse farmers.
Shively (1999)	Philippines	Investigate economic risk between contour hedgerows and conventional tillage systems on hillside corn farms.	SDRF	• Hedgerows preferred by risk averse farmers who have relative risk aversion in the range 3.0 to 5.5.
		Marketing alternatives		
Elrod et al. (2008)	Texas, USA	Evaluate the most risk efficient marketing options which were suitable for risk averse cotton farmers.	SERF	• Put option strategy was stochastically efficient over the other marketing options and preferred by the risk averse cotton farmers in both irrigated and dryland areas.

Table 3.1 Summary of the economic risk efficiency in agriculture studies using stochastic approaches (cont.)

Author(s)	*Country/Area of the studies*	*Major purpose(s)*	*Stochastic approaches*	*Results of the study*
Donnelly and Noel (2006)	California, USA	Assess the optimal forward contracting strategy to maximize returns and minimize risk for the lettuce farmers	SERF	• A 100 per cent contract was the most risk efficient strategy and suitable for risk averse lettuce farmers.
		Financial alternatives		
Lau (2004)	Texas, USA	Investigate the most risk efficient financial project feasibility of ethanol factory investment in three different regions.	SERF	• The central region of Texas was the most suitable area for the ethanol plant to be built and would be preferred by the risk averse investors.
Richardson et al. (2007)	Netherlands and USA	Investigate and compare economic returns associated with risk of the dairy farms in both countries.	SERF	• Risk averse Dutch dairy farmers preferred to liquidate their farm operations in the Netherlands and invest in dairying in the US.
Nartea and Webster (2008)	New Zealand	Analyse the appropriate farmers' portfolio options to include other financial investments.	SERF	• Highly risk averse farmers would prefer to diversify their farm asset portfolios, while incorporate bonds rather than shares in portfolios would be suitable for somewhat risk averse farmers.

Chapter 4
Research Methodology

The chapter is organized as follows. Section 4.1 discusses the research design of the study. The locale of the study is presented in Section 4.2. The methodological approach used in collecting the data as well as the sample selection and the instrument administration are outlined in Section 4.3. In the following section, the data limitations are described. Section 4.5 discusses data processing and analysis.

4.1 Research design

The approach used to analyse the data in this study can be addressed as follows:

a) What is the most risk efficient farming system suitable for Thai smallholder farmers?

b) What are the risk preferences of Thai smallholder farmers?

c) What are the major sources of risk that Thai smallholder farmers confront and how do they manage and cope with those risks?

Different farming systems are thought to produce significant income variation and risk. In order to investigate a risk efficient farming system, the risk efficiency approach was employed to compare economic variability between different farming systems. The comparison of the risky options using risk efficiency criteria required information on a whole-farm stochastic simulation to analyse and assess income risk differences (Lien et al., 2006). Many previous studies employed farm-level panel data on yield and price of the optional farming systems from the scientific experimental station database to specify their stochastic farm models (Lien et al., 2006; Pendell et al., 2007).

However, due to insufficient relevant information about smallholder farm-level panel data in Thailand, field surveys were employed to estimate the average net farm income of each farming system, supplemented by historical data on yields and prices from the Office of Agricultural Economics (OAE) database. These data were used to generate the whole-farm stochastic models in the study areas.

In addition, it was interesting to elicit the risk preferences of smallholder farmers in Thailand because risk attitudes represent farmers' decision behaviour in managing their farm. The farmers' risk attitude will be measured using the equal likely certainty equivalent (ELCE) method (Hardaker, Huirne, et al., 2004). This method obtains the individual certainty equivalent (CE) for a series of risky outcomes and then matches the CEs with the utility values. The risk aversion coefficient will be evaluated and compared using several utility function forms. The choice of utility function will directly affect the classification of attitudes toward risk.

Risky environments vary and depend on farm type, geography and other factors, and influence farm business in different ways. A weighted Likert scale was used to measure Thai farmers' perceptions on sources of risk and risk management strategies. Each scale indicates the respondent's level of agreement with a statement measured on a five point scale, with '1' not important, '5' extremely important and '3' quite important. The number of sources of risk and risk responses were grouped and reduced using factor analysis. The relationship of socio-economic characteristics and risk perceptions was also examined.

4.2 Locale of the study

The investigation was conducted in the central and north-east regions of Thailand. The two regions are dissimilar in terms of natural resources, economic development and income distribution. The north-east has nearly 35 per cent of the total land area of the country. Roughly 58 million rai (9.3 million ha) or 55 per cent, is categorized as the arable (OAE, 2009). The population of the north-east was estimated at around 23 million in 2007; around one third of the Thai population lives in this region (NESDB, 2008a). Although, the north-east has the biggest share of agriculture land, most farmers in the region are poor.

In 2007, the NESDB reported the gross regional product (GRP) at current market prices of the north-east at approximately 904,119 million baht. The income from the agricultural sector accounted for 20 per cent of the north-east GRP or nearly 183,977 million baht. Though the GRP of the north-east is greater than that of the central region, the GRP per capita of the north-east is considerably smaller than that of the central region (NESDB, 2008a). Nearly half the population in the north-east lives in the rural area and engages in agriculture. In 2007, the number of farm units in the north-east was estimated at 2.7 million farms (OAE, 2009). The average annual net farm income of a farmer in the north-east is lower than in the central area and the lowest in the country (around 21,399 baht/household/year) (OAE, 2009).

In the north-east agricultural production is relatively small compared with the central region with significantly lower yields of some major cash crops; this may explain the low net farm income in the north-east (see Table 4.1). The poor productivity of soil, inadequate rainfall and lack of water resource infrastructure have been identified as vital constraints that affect the low crop yields in the north-east (Floch, Molle, & Loiskandl, 2007; Suetrong & Pairintra, 1989).

Most soils in the north-east are categorised as Solodize-Solonetz. The common features of this type of soil are sandy, low fertility, highly acid and poor water-holding capacity. On the other hand, soils in the central area are alluvial soils that are poorly drained and moderately high fertility. The alluvial soils appear suitable for rice cultivation (Attanandana, Kyuma, & Kunaporn, 1996; Land Development Department, 2009). In terms of irrigation development, in 2007, public irrigation systems in Thailand covered an area of approximately 28 million rai (4.5 million ha). Roughly 11.3 million rai (1.8 million ha) is located in the central area with 41 large scale irrigation schemes. However, the development of water resource infrastructure in the north-east is slow covering an agricultural area of roughly 5.9 million rai (0.9 million ha) (RID, 2008).

The different farming resources and economic situations were used to select the two regions as the study areas. These conditions may have a significant effect on farming patterns, particularly for smallholder farmers. Therefore, the best and worst characteristics of smallholder farmers between both two regions provide a basis for comparison of the results using risk efficiency criteria. In addition, the central and north-east regions are the major agricultural regions of Thailand. Both regions cover approximately 65 percent of farming area of the country. Over 60 percent of Thai farmers live in these two regions (see Table 1.3). These are the rationales why the central and north-east regions were selected as the study location.

Table 4.1 Main agricultural features of the central and north-east regions in Thailand

Main features	*Central*	*North-east*
Gross regional product (GRP) at current market prices in 2007 [a] (millions baht)	611,413	904,119
- Agriculture	38,892	183,977
- Non-agriculture	572,521	720,142
GRP per capita in 2007 [a] (baht)	203,245	40,144
Population in 2007 [a] (1,000 persons)	3,008	22,522
Total land area in 2007 [b] (1,000 rais)	64,938	105,534
Total arable area in 2007 [b] (1,000 rais)	25,831	57,736
Number of farms in 2007 [b]	881,830	2,695,472
Average annual net farm income in 2007 [b] (baht/household/year)	83,814	21,399
Production and yields of selected cash crops in 2007 [b]		
Wet rice		
- production (1,000 tonnes)	5,515	10,378
- yield (kilograms/rai)	592	338
Dry rice		
- production (1,000 tonnes)	3,910	478
- yield (kilograms/rai)	714	535

Table 4.1 Main agricultural features of the central and north-east regions in Thailand (cont.)

Main features	*Central*	*North-east*
Cassava		
- production (1,000 tonnes)	8,433	13,715
- yield (kilograms/rai)	3,803	3,607
Maize		
- production (1,000 tonnes)	686	666
- yield (kilograms/rai)	629	550
Sugarcane		
- production (1,000 tonnes)	22,850	22,469
- yield (kilograms/rai)	10,100	9,829
Soil type [c]	Alluvial soils	Solodized-Solonetz
Irrigation area in 2007 [d] (1,000 rai)	11,282	5,873

1 rai = 0.16 ha

Source: [a] The Office of the National Economic and Social Development Board (2008a)
[b] Office of Agricultural Economics (2009)
[c] Land Development Department (2009)
[d] Royal Irrigation Department (2008)

4.3 Data collection

The data for this study were collected from two main sources: (a) primary data gathered from a field survey sample of smallholder farmers in the central and north-east regions of Thailand; and (b) secondary data obtained from government annual statistical reports.

4.3.1 Selection of samples

The sampling frame for this study focused on smallholder farmers in the central and north-east regions of Thailand. A smallholder farmer is defined as a farmer who has a farming area less than 30 rai (4.8 ha). Purposive random sampling was employed to classify a particular group of respondents from a certain portion of the population.

The sample selection process is as follows. First, the provinces in each region were separated into two main groups: (a) the provinces with large and medium irrigation systems and (b) the provinces in the rain-fed area. Secondly, purposive sampling was employed to select smallholder farmers in each group. This procedure ensured that the sample covered smallholder farmers of both the irrigated and rain-fed areas in the central and north-east regions.

The sample size in this study was calculated from the following formula given by Yamane (1973):

$$n = \frac{N}{1 + Ne^2} \tag{4.1}$$

Where:

n = sample size;

N = population size; and

e = acceptable error (per cent).

The population, N, of smallholder farmers is based on the 2003 Thailand agricultural census. The entire number of smallholder farmers is roughly 747,641 in the central region and 2,394,274 in the north-east (see Table 4.2). Using a 5 per cent acceptable error, the sample size, n, is approximately 400 in each region. However, the sample size can be different from that calculation, which is based on the given cost and other limited conditions (Padilla-Fernandez, 2000; Scheaffer, Mendenhall, & Ott, 2006).

Table 4.2 Populations of farmers in the central and north-east Thailand by size holding, 2003

Size of total areas of holding (rai)	*Whole Kingdom*	*Central*	*North-east*
≤ 6	1,372,215	256,848	415,012
6-9	816,588	88,341	393,074
10-39	2,970,571	402,452	1,586,188
40-139	625,917	142,825	252,561
≥139	29,388	12,293	6,556
Total	5,814,679	902,759	2,653,391

[a] 1 rai = 0.16 ha

Source: National Statistical Office (2006)

Currently, the central and north-east regions consist of 25 and 19 administrative provinces, respectively. This study was conducted in 4 provinces of the north-east including Khon Kaen, Kalasin, Chaiyaphum and Nakorn Ratchasima. The criterion used to select those provinces was the large scale irrigation system, and the Nongwai and Lumpoa project, located in the east of Khon Kaen and Kalasin provinces. In contrast, some areas in west Khon Kaen, Chaiyaphum and Nakorn Ratchasima represent the rain-fed agriculture of the north-east.

The most provinces in the central region are located in irrigated areas. Ayutthaya, Patum Thani, Sing Buri and Lop Buri provinces were selected to represent irrigated agriculture in the central region. However, in some parts of Lop Buri province, rain-fed agriculture data were collected. The selected areas are shown in Figure 4.1.

The villages and smallholder farmers were purposefully selected with the assistance of the agricultural office staff and the heads of the village in the study areas. This study consulted and sought assistance from OAE staff during the field survey in the central region. This was because the staff members are familiar with farmers and the local farming situation.

Therefore, the availability of these staff, the limited time and transportation costs were also considered. The distribution of the respondents in this study is shown in Table 4.3.

Table 4.3 Distribution of respondents in central and north-east Thailand categorized by province and farm location

Region	*Province*	*Respondent's farm located in*		*Total number of respondents*
		Irrigated area	*Rain-fed area*	
Central		*294*	*106*	*400*
	Lop Buri	114	106	220
	Ayutthaya	121	-	121
	Pathum Thani	40	-	40
	Sing Buri	19	-	19
North-east		*168*	*232*	*400*
	Khon Kaen	89	157	246
	Kalasin	79	18	97
	Nakon Ratchasima	-	34	34
	Chaiyaphum	-	23	23
Total				*800*

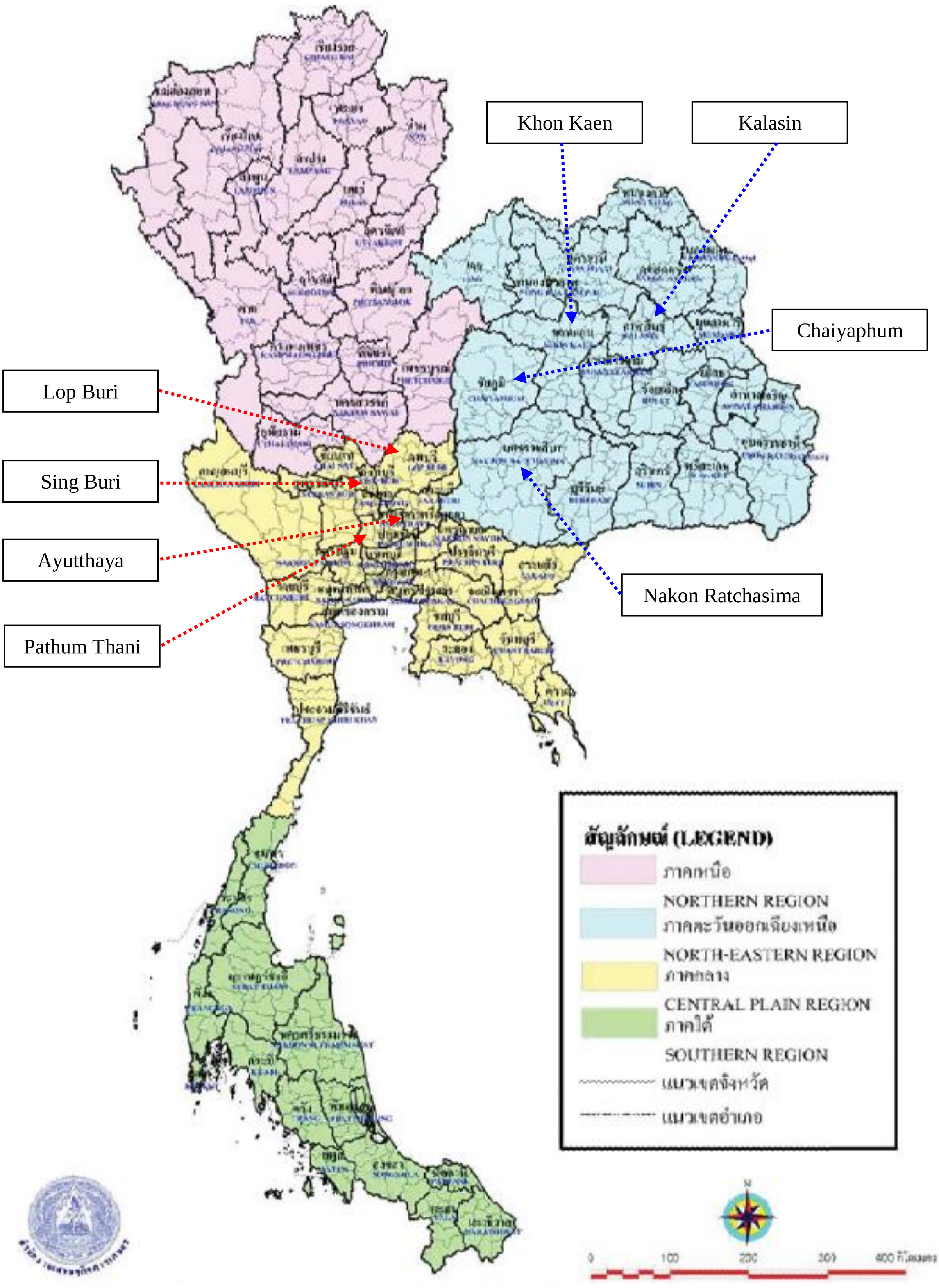
Source: Field survey, 2009

4.3.2 Questionnaire design

The structured interview questionnaire method was employed to elicit information from the smallholder farmers. The questionnaire is divided into six major sections: (1) general farm information; (2) farming system; (3) sources of risk on farm; (4) risk management strategies; (5) farmer's utility elicitation; and (6) socio-economic profile of the farmers. The questionnaire comprised of closed-ended questions, multiple choice questions and open-ended questions (see Appendix A).

The first section of the questionnaire contained questions relating to general information about the farm including farm size, owner status, farm finance and the details of on-farm assets. The second section was designed to obtain information about the agricultural activities on the farm. The respondents were asked to specify the main farm activities on the farm and the crop rotation. The areas allocated to each crop, total production, price of crop sold and production cost for each crop were obtained in order to generate a small farm cropping pattern and revenue.

Figure 4.1 Map of Thailand and the selected study areas



Source: Modified from Office of Agricultural Economics (2009)

Section three focused on the sources of on-farm risk. This section measure how important the sources of risk are to small farm operations. The scale ranged between '1' not important, to '5' extremely important through '3' quite important. Similarly, in section four, the attitudes toward the importance of risk management options in managing small farms were assessed on a scale, with '1' not important, '5' extremely important and '3' quite important. The sources of risk and risk management variables were adapted from Martin (1993); Martin and McLeay (1998) and Pellegrino (1999). Section five contained a series of hypothetical risky lottery tickets with equal probability that were used to derive the respondent's utility function following the ELCE elicitation method. The last section included questions on the respondent's demographic characteristics and the household's income.

The draft questionnaire was sent for consultation to three academic experts in agricultural economics and farm management at Kasetsart and Khon Kaen Universities, Thailand. Constructive suggestions about some content and the sequence of questions improved the questionnaire. The questionnaire was translated into Thai and pre-tested.

The pre-test was conducted with 30 sample farmers in Chaiyaphum province, Thailand, with the assistance of DLD staff. The purpose of this pre-test was to determine the effectiveness of the questionnaire in terms of wording and the sequence of questions. The length of time for interviewing each respondent was also considered. Most interviews were completed in an average of 30 minutes.

According to the pre-test results, the range of lower and upper decision boundary of the risky lottery ticket that follows the ELCE method produced major concern. It was found that, during the pre-test, when the range employed was 0 to 25,000 baht, the sampled farmers were less interested in participating. After careful consideration, the range of the lower and upper decision boundary was changed to 0 to 100,000 baht in the final survey to obtain better participation for the respondent's utility function elicitation.

4.3.3 Interviewing procedure

The field survey was conducted from January to April 2009. Face-to-face interviews were employed to gather relevant information from the respondents. Five research assistants were recruited for the field survey from the Department of Agricultural Economics, Faculty of Agriculture, Khon Kaen University. The research assistants were trained in a workshop for three days before administering the surveys. The training was to brief them about the general information on the purpose of the study, details of each question and the interview technique. The pilot survey was performed on the last day of the workshop to ensure that the research assistants clearly understood all questions in the questionnaire, particularly the ELCE elicitation method. Problems relating to the questionnaire were reported and discussed during the pilot surveys to generate the final version of the questionnaire. The research assistants were required to strictly follow the ethical regulations of Lincoln University Human Ethics Committee, including the anonymity and confidentiality requirements, completely voluntary participation of the respondents and the right of participants to withdraw from the interview at any time.

The participants in this research were smallholder farmers who are resource-poor farmers and have limited on-farm activity diversification. The researcher sought help from the agricultural staff and heads of the villages to determine qualified participants, in particular for two stages. First, the researcher contacted the provincial office of agriculture staff in the study areas and requested them to provide information from their statistics database on the names of villages that had a high number of smallholder farmers in both the irrigated and rain-fed areas. Secondly, the researcher purposefully selected villages from the list and then the researcher contacted the head of each village and briefed them about the research. The researcher asked the head of the village to announce the research study on the public address system in the village a few days before the field survey was to start and to invite smallholder farmers to participate in the interview. The smallholder farmers who were willing to participate in this study were gathered together in a central location, such as head of the village's house, on the appointed date and time. However, some interviews took place at the farmer's house or on a farm visit.

The interviews performed by the researcher and research assistants relied on the individual participant's permission. Before the interview, each participant was provided with brief information by the interviewers including the purpose of the study, activities and time required to complete the interview, the anonymity and confidentiality and the right to stop and withdraw from the interview at any time. The participants were asked to sign the consent form. The participant's name was not included on the questionnaire. Codes were employed to identify each participant and farm location.

During the field surveys, some participants withdrew from the interview because they thought the interview was too difficult or they did not have enough time to complete it. These participants were replaced to maintain the sample size. The information on crops and livestock production and prices of products sold collected from the respondents was based on crop year 2008. All completed questionnaires were manually edited and then coded and entered in Microsoft Excel.

4.3.4 Secondary data

The time series data on yields and prices of each individual crop at provincial level in the study area were collected from the Centre of Agricultural Information, OAE database. The historical data covered the 1998-2008 crop years. The resulting data sets were used for the cumulative probability distribution of price and yield for each individual crop and then fitted into the stochastic simulation model to generate the risk efficiency for each alternative farming system.

4.4 Data limitations

Some minor problems occurred during the field surveys, especially with the ELCE interview, because the procedure in this method required the respondents to play a "gambling game". Some respondents refused to participate in this game because of their religious beliefs. This is drawback of the ELCE method cited by Hardaker, Huirne et al. (2004). In addition, some respondents are severely risk averse. Most selected only the alternative that obtained cash and thus terminated the game in the process. Therefore, the remaining 228 respondents in the north-east and 207 respondents in the central region were used in the analysis of risk aversion coefficients. Those respondents had completed all the required data points.

4.5 Data analysis

4.5.1 Descriptive statistics

Descriptive statistics are employed to describe the general attributes and to summarize the pertinent information about the respondents. Household and farm characteristics of the respondents were examined using frequency distribution and arithmetic means. Tests of statistically significant differences, such as independent t-test and chi-square test, were used to determine the differences between the groups of smallholder farmers in the central and north-east regions.

4.5.2 Annual net farm income calculation

The annual net farm income of each alternative farming system that produced by the sampled smallholder farmers in the central and north-east regions in crop year 2008 was calculated using the following formula (Lien et al., 2006; Mustafa, 2006):

$$FR_i = (P_i Y_i) L_i \tag{4.2}$$

Where:

FR_i is the farm revenue from the specific farm activity in baht;

P_i is the price of product sold in baht per kg for rice and arable crops and per head for animals;

Y_i is the yield per rai of the specific crop activity in kg and per head for animals;

L_i is area in rai of the specific crop in farm; and

i is the index for the different farm activities.

The total variable cost for each farm activity was calculated as follows:

$$TVcr_i = LPC_i + PLC_i + HVC_i \tag{4.3}$$

$$TVan_i = FDC_i + OTC_i \tag{4.4}$$

Where:

$TVcr_i$ is the total variable cost for the specific crop activity on farm in baht;

$TVan_i$ is the total variable cost for the specific animal activity on farm in baht;

LPC_i is the total land preparation cost for the specific crop activity in baht;

PLC_i is the total planting cost for the specific crop activity in baht;

HVC_i is the total harvesting cost for the specific crop activity in baht;

FDC_i is the total feed cost for the specific animal activity in baht;

OTC_i is the other costs for the specific animal activity in baht; and

i is the index for different farm activities.

Therefore, the gross margin is calculated as follows:

$$GM_i = FR_i - TV_i \tag{4.5}$$

Where:

GM_i is the gross margin in baht of the specific farm activity; and

i is the index for the different farm activities.

The total fixed costs of a smallholder farm are given as follows:

$$TF = LT + RT + FAD \tag{4.6}$$

Where:

TF is the total fixed costs in baht;

LT is the annual land taxes in baht;

RT is the annual land rental in baht; and

FAD is the annual farm assets depreciation which are estimated using the straight line depreciation method.

The annual whole farm income was estimated using the following formula:

$$A = \sum_{i=1}^{k} [GM_i] - TF \quad (4.7)$$

Where:

A is the whole farm income estimated from the different farm activities in baht;

GM_i is the gross margin from each farm activity in baht; and

TF is the total fixed costs in baht.

4.5.3 Sources of risk and risk management strategies analysis

The information on the sources of risk and risk management strategies perceptions obtained from the respondents using a five-point Likert scale were analyzed in two steps:

First, exploratory factor analysis (EFA) was used to capture the information on the interrelationships among the set of variables. This technique enabled the researcher to manage and reduce the number of original variables into a smaller group of a new correlation dimensions (factors), which are linear combinations of the original variables (Hair, 2006; Pallant, 2007). The EFA summarized and reduced the 19 and 16 variables involved with the risk sources and risk management responses, respectively in this study.

The Kaiser-Meyer-Oklin (KMO) method measured the appropriateness for factor analysis of both data sets. The KMO index varies from 0 to 1, with results of 0.6 or greater being suitable for factor analysis. Also, the latent root criterion (eigenvalue > 1) was estimated to identify how many factors in each data set to extract. After the number of factors had been identified, the orthogonal (varimax) rotational approach was performed in order to minimize the number of variables that have high loadings on each factor. A factor loading of ± 0.4 was employed as a cut off criterion to determine the inter correlation among the original variables. In addition, Cronbach Alpha was employed to evaluate the internal consistency of each factor (Hair, 2006). Following factor analysis, the summated scale of each factor for each group of respondents was prepared for subsequent analysis.

Secondly, the relationships of interest between the socioeconomic variables and the perception of risk sources and risk management strategies of the smallholder farmers were considered. Multiple regression was employed to evaluate the influence of farm and farmer characteristic variables on the smallholder farmers' risk perception and risk management responses. Preliminary analyses were carried out to verify there was no violation of the multiple regression assumptions. Normality, linearity, multicollinearity and homoscedasticity were examined and are discussed in the results chapter.

The model specification for the farmer's perception of risk source with socioeconomic variables is postulated as follows:

$$S_i = b_0 + b_1AGE + b_2GEN + b_3EDU + b_4EXP + b_5OFFW + b_6FSIZ + b_7INCM + b_8LOC + b_9FINC + b_{10}AHIN + b_{11}HSIZ + e \quad (4.8)$$

The model for risk management responses with socioeconomic variables is given as follows:

$$R_i = b_0 + b_1AGE + b_2GEN + b_3EDU + b_4EXP + b_5OFFW + b_6FSIZ + b_7INCM + b_8LOC + b_9FINC + b_{10}AHIN + b_{11}HSIZ + e \quad (4.9)$$

Where:

S_i is sources of risk i (from factor analysis);

R_i is risk management strategies i (from factor analysis);

b_i is regression coefficient;

AGE is 1, if the respondent's age is over 40 years old, 0 otherwise;

GEN is 1, if respondent is male, 0 if female;

EDU is 1, if the highest education of the respondent is high school and higher, 0 if primary school education or less;

EXP is 1, if the farming experience is over 30 years, 0 otherwise;

OFFW is 1, if the respondent has off-farm work, 0 if no off-farm work;

FSIZ is farm size;

INCM is net farm income;

LOC is 1, if the respondent's farm is located in central region, 0 if a farm located in north-east region;

FINC is 1, if farm has a loan, 0 if farm without a loan;

AHIN is 1, if the annual household income greater than 90,001 baht, 0 otherwise;

HSIZ is household size; and

e is error term.

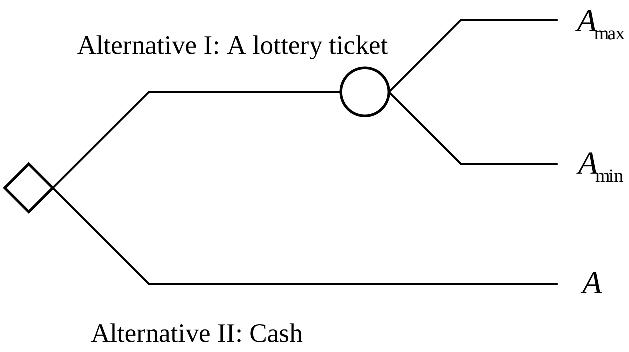
4.5.4 Farmers' utility elicitation

The ELCE method, which is generally the procedure used for eliciting an individual utility function, was incorporated in this study to determine the risk attitudes of smallholder farmers (see Section five in Appendix A). The details of this procedure are discussed below.

According to Hardaker, Huirne et al. (2004), the ELCE method obtains certainty equivalent (CE) from a series of risky outcomes with the equal probabilities of 0.5. The CEs are correlated with the utility values of 1 (the best outcome) to 0 (the bad outcome). Therefore, this study assumes the lowest outcome that a farmer gets from the lottery ticket is 0 baht, and the highest is 100,000 baht. We set $U(0)=0$ and $U(100{,}000)=1$.

The elicitation procedure involved asking the respondent to choose between alternative I, a lottery ticket, and alternative II, a sure sum of money (A) (see Figure 4.2). The lottery tickets offered of a chance to win either 100,000 baht (A_{max}) or 0 baht (A_{min}) with a 50:50 probability. A is arbitrarily selected along with A_{max} and A_{min} which are considered the upper and lower decision boundary between alternative I and II. Following this, the respondent was asked to choose which alternative he or she preferred. If the respondent chose cash, then A is decreased by some amount and process is repeated. In contrast, if the respondent chose a lottery ticket, then A is increased by some amount and the process is repeated. The value of A changes until the respondent feels indifferent between the alternatives. This value is called the CE for the risky incident. After the first CE was obtained, the same procedure as described above is repeated. We continued to present the respondent with another lottery ticket in accordance with several different A_{max} and A_{min} scenarios until the seven CE values were completely elicited and the process is completed.

Figure 4.2 Certainty equivalent elicitation procedure



Source: Modified from Akcaoz & Ozkan (2005)

The exact computation steps in order to correlate the utilities with the CE values for each respondent are illustrated in Table 4.4. The notation in Table 4.4 $a,b,c,...,g$ denotes the sequence of seven CE values for the risky outcomes obtained from the ELCE procedure.

The ELCE interviews were carefully conducted by the researcher and trained research assistants because of the awareness of interviewer bias on the elicitation of the utility function

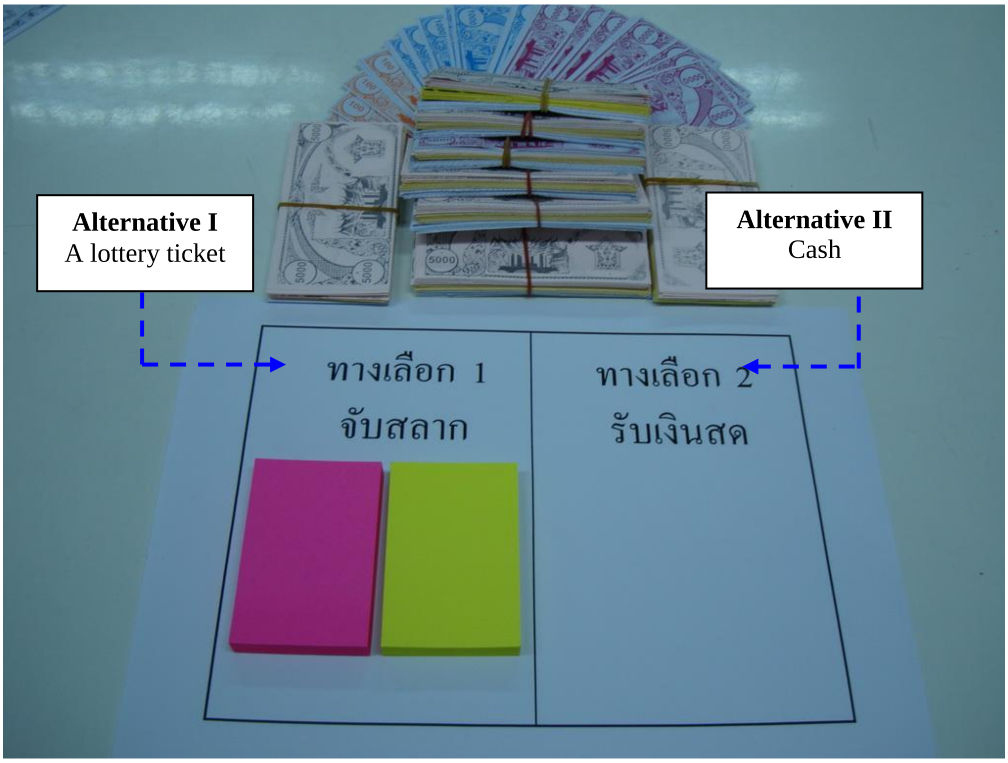
(Binswanger, 1980). In addition, counterfeit notes (similar to Thai banknotes) and the two different colour post-it papers were employed during the ELCE interview process (see Figure 4.3). The counterfeit notes were used to ensure that the respondents paid attention to the amount of money that was offered by the interviewer. The two different colour papers helped prevent confusion among the respondents regarding the 50:50 probabilities of the lottery ticket. This was helpful for the respondents with limited literacy.

Table 4.4 Elicitation of CEs in approximating a respondent's utility function

Step	*Elicited CE*	*Utility calculation*
1	Setting a scale	$U(0)=0\,;U(100{,}000)=1$
2	$(a;1.0)\sim(0,100{,}000;0.5,0.5)$	$U(a)=0.5U(0)+0.5U(100{,}000)=0.5$
3	$(b;1.0)\sim(0,a;0.5,0.5)$	$U(b)=0.5U(0)+0.5U(a)=0.25$
4	$(c;1.0)\sim(0,b;0.5,0.5)$	$U(c)=0.5U(0)+0.5U(b)=0.125$
5	$(d;1.0)\sim(0,c;0.5,0.5)$	$U(d)=0.5U(0)+0.5U(c)=0.062$
6	$(e;1.0)\sim(100{,}000,a;0.5,0.5)$	$U(e)=0.5U(100{,}000)+0.5U(d)=0.75$
7	$(f;1.0)\sim(100{,}000,e;0.5,0.5)$	$U(f)=0.5U(100{,}000)+0.5U(e)=0.875$
8	$(g;1.0)\sim(100{,}000,f;0.5,0.5)$	$U(g)=0.5U(100{,}000)+0.5U(f)=0.937$

Source: Modified from Hardaker, Huirne et al. (2004)

Figure 4.3 Counterfeit notes and two different colour papers used in the ELCE interview



4.5.5 Measurement of risk aversion coefficients

Risk aversion measures a person's willingness to accept a bargain with an uncertainty payoff rather than another bargain with more certainty with the probability of a lower expected payoff. This indicates that the shape of a person's utility function affects risk aversion (Hardaker, Huirne, et al., 2004).

Previous studies have criticized the effect of the choice of utility functional form on the classification of risk preference results (Binici et al., 2003; Torkamani & Haji-Rahimi, 2001; Zuhair et al., 1992). In order to avoid ambiguous results in choosing a particular functional form that exhibits the respondents' attitude towards risk, different utility functions should be employed to analyse their performances in terms of risk preference classification. The utility function forms, such as the cubic function, negative exponential function, power function and expo-power function, were used to estimate and compare risk preference classification results in this study. We chose the specific functional forms because it is easier to estimate the parameters of the function and imposes the least restrictive assumptions. The general form of each utility function and its examination of the Arrow-Pratt absolute risk aversion coefficient ($r_a(w)$) are summarized in Table 4.5.

Table 4.5 General form and parameter restrictions of the four different utility functions used in this study and the absolute risk aversion coefficients estimation

Utility function	*General form*	*Absolute risk aversion calculation*
Cubic function	$U(w) = a + bw + cw^2 + dw^3$	$r_a(w) = -\left[\dfrac{(2c + 6dw)}{b + 2cw + 3dw^2}\right]$
Negative exponential function	$U(w) = 1 - \exp(-cw), c > o$	$r_a(w) = c$
Expo function	$U(w) = \alpha + \beta w^{\gamma}, 0 < \gamma < 1$	$r_a(w) = -(\gamma - 1)w^{-1}$
Expo-power function	$U(w) = \gamma - \exp(-\beta w^{\alpha})$, $\gamma > 1, \alpha \neq 0, \beta \neq 0, \alpha\beta > 0$	$r_a(w) = \dfrac{(1 - \alpha + \alpha\beta w^{\alpha})}{w}$

Note $U(w)$ is the utility with respect to wealth (w); $r_a(w)$ is the Arrow-Pratt risk aversion coefficient; and $a, b, c, d, \alpha, \beta, \gamma$ are parameters.

The sequences of data points elicited from the ELCE for each respondent were regressed using the non-linear least square (NLS) method to fit four different utility functions. The statistical goodness of fit assessment, R^2, was tested to verify the curve fit. Any violation of parameters' restrictions in each functional form was also tested. Subsequently, $r_a(w)$ was computed using the estimated parameters of the four utility functions. The $r_a(w)$ for the cubic function, expo function and expo-power function were calculated at the midpoints of the ranges used to elicit the respondents' utility function except the $r_a(w)$ for the negative exponential is independent of any level of wealth. All the tests were carried out using Eviews version 6.0. The performance comparison of the four utility functions in predicting the risk preferences of smallholder farmers are discussed in the results chapter.

It is also interesting to investigate the risk aversion characteristics of the smallholder farmers in Thailand. Previous studies (e.g. Binswanger, 1980; Shahabuddin, Mestelman, & Feeny, 1986) employed multivariate regression analysis to estimate the relationship of risk aversion coefficients and demographic variables of farmers and farm households. The categorization of wealth and non-wealth variables influencing the risk aversion of farmers' examined in previous studies is summarized in Table 4.6.

Table 4.6 Socioeconomic variables affecting a farmer's risk aversion from previous studies

Variables	*Moscardi and Janvry (1977)*	*Dillon and Scandizzo (1978)*	*Binswanger (1980)*	*Shahabuddi et al. (1986)*	*Bicini, Koc and Bayaner (2001)*	*Gómez-Limón, Arriaza and Riesgo (2003)*
Studies location	Mexico	Brazil	India	Bangladesh	Turkey	Spain
			Non-Wealth			
Age	✓	✓	✓	✓	✓	✓
Household size	✓	✓		✓		✓
Education		✓	✓	✓	✓	✓
Gender			✓			
Farm size				✓		✓
Land ownership			✓			✓
			Wealth			
Farm income	✓		✓			✓
Off-farm income		✓	✓	✓		
Total assets			✓	✓	✓	

With reference to the literature, multiple regression analysis was used to investigate the relationship between the socioeconomic characteristics and the variation of risk aversion coefficients of smallholder farmers. The equation can be written as follows:

$$Z_i = b_0 + b_1 AGE + b_2 GEN + b_3 EDU + b_4 HSIZ + b_5 FSIZ + b_6 INCM + e \qquad (4.10)$$

Where:

Z_i is the absolute risk aversion coefficient for farmer i;

b_i is the regression coefficient;

AGE is 1, if the respondent's age is over 40 years old, 0 otherwise;

GEN is 1, if respondent is male, 0 if female;

EDU is 1, if the highest education of the respondent is high school and higher, 0 if primary school education or less;

$HSIZ$ is household size;

$FSIZ$ is farm size;

$INCM$ is net farm income; and

e is error term.

4.5.6 Stochastic efficiency with respect to a function (SERF) analysis

Risk efficiency comparisons among the farming system alternatives of smallholder farmers in this study were assessed using the SERF method. According to Hardaker, Huirne et al. (2004), SERF ranks the farming systems options using the certainty equivalent (CE) over a range of values of risk aversion.

The CE for each risky alternative relies on the particular utility functional form specified. The chosen utility function can be calculated, depending on the degree of absolute risk aversion (r_a) and stochastic outcome (x), as follows (Hardaker, Huirne, et al., 2004):

$$U(x,r_a) = \int U(x,r_a) f(x)dx \tag{4.11}$$

Where:

$U(\cdot)$ is a utility function, and the expression is estimated for selected values of r_a in the range of r_L to r_U.

Transforming the utilities to CEs can be achieved by performing the reverse of the utility function, described as (Hardaker, Huirne, et al., 2004):

$$CE(x,r_a) = U^{-1}(x,r_a) \tag{4.12}$$

The negative exponential utility function was chosen to estimate the coefficient of absolute risk aversion of Thai farmers and the relevant range used in the SERF analysis. This functional form exhibits constant absolute risk aversion (CARA). In addition, this utility function conforms to the assumption that the farmers desire less risk to more, given the same expected outcome (Pendell et al., 2007). Hence, the following equations are used to approximate the expected utility, the negative exponential utility function, and the CE for a given absolute risk aversion and can be expressed as follows (Hardaker, Huirne, et al., 2004):

$$U(x,r_a) = \sum_i (F_{i+1} - F_i)\left[1 - \{\exp(-r_a x_i) - \exp(-r_a x_{i+1})\}/ r_a (x_{i+1} - x_i)\right], r_L \le r_a \le r_U \tag{4.13}$$

$$CE = -\ln\{1 - U(x, r_a)\}/r_a \tag{4.14}$$

The CEs derived from the calculation corresponding to the values of r_a for each farming system are plotted on a graph. In order to determine which is the most risk efficient set, the farming system option that has the highest CE in the relevant range of r_a will be generated as the most risk efficient alternative (Hardaker, Huirne, et al., 2004).

The stochastic simulation model employed to evaluate the empirical probability distribution for annual net farm income ($\tilde{A}$) that incorporates equations 4.13 and 4.14 for each farming system can be described as follows (Lien et al., 2006; Tzouramani, Karanikolas, & Alexopoulos, 2008):

$$\tilde{A} = \sum_{i=1}^{k}\left[(\tilde{P}_i\tilde{Y}_i)L_i + \tilde{C}_i H_i\right] - TV - TF \tag{4.15}$$

Where:

$\tilde{P}_i$ is the per kilogram stochastic price of crop i in the farming system (in baht);

$\tilde{Y}_i$ is the per rai stochastic yield of crop i (in kilograms);

L_i is the deterministic effective areas used to grow crop i in crop year 2008 (in rai);

$\tilde{C}_i$ is the per head stochastic price of animal i in the farming system;

H_i is the deterministic heads of livestock i sold in crop year 2008;

TV is the deterministic total variable costs for the farming system in crop year 2008 (in baht); and

TF is the deterministic total fixed costs for the farming system in crop year 2008 (in baht).

The SERF analysis in this study was programmed and simulated using the SIMETAR (Simulation & Econometrics to Analyze Risk) developed by James W. Richardson, Keith D. Schumann and Paul A. Feldman since 1997 (Simetar Inc, 2007). SIMETAR was employed to simulate stochastic net farm income, rank risky farming system alternatives over different magnitude of farmers' risk preferences and summarizes those results graphically. SIMETAR was also used in previous empirical studies (e.g. Lien et al., 2006; Pendell et al., 2007) to simulate stochastic models and rank a set of risky alternatives.

Chapter 5

Perceptions of Sources of Risk and Risk Management Strategies - Results and Discussion

This chapter presents the empirical results and discuss the findings on risk perceptions and risk management strategies. The chapter is structured into five sections. The results of the socioeconomic characteristics of the farmers are discussed in Section 5.1. In the following section, farmers’ perceptions of sources of risk and risk management strategies are discussed. The results of the exploratory factor analysis are described in Section 5.3. Section 5.4 discusses the association between the farmer’s characteristics and the source of risk and risk management strategy components. The last section summarizes the findings.

The results and findings in each section are compared with the results from each of the regions studied. In addition, comparisons of the results between the irrigated and rain-fed areas of those regions are also investigated.

5.1 Socioeconomic characteristics of the farmers

The aggregated statistics of the central and north-east region farmers are presented in Table 5.1. A sample t-test and a chi-square test were employed to test the differences between the characteristics of the farmers in the two regions.

The data in Table 5.1 show the central and north-east region farmers have dissimilar characteristics. Comparisons of the farmers’ characteristics between the two regions (both the t-test and chi-square) are significantly different, except for gender, household size and finance used for the farm business. The findings indicate that the central and north-east region farmers generally differ in terms of personal, farm characteristics and income distribution.

The age group distribution indicates that the majority of the farmers in both regions were over 40 years old. Around 40 per cent of the north-east region farmers were over 60 years old, whereas 42 per cent of the central region farmers were between 41-50 years old. The age distribution between the farmers in both regions was significantly different. The north-east region farmers were more likely to be older than the central region farmers. Nearly half of the farmers in the north-east had been involved in agricultural work for over 40 years. This implies that younger farmers are rare especially in the north-east. This may be a result of the rural-to-urban migration problems in Thailand (see Section 2.1).

Around 75 per cent of the farmers in both regions graduated with a primary education and about three per cent were illiterate. The result indicates that the central region farmers had higher levels of education than the north-east farmers ($P < 0.01$). Mustafa (2006) argued that the educational level of farmers affected their decision making capacity. A higher educated farmer was expected to perform better than an uneducated farmer in terms of management skills and farm resource allocation to maximize farm profitability.

The average farm size of the farmers in the central region was 21.40 rai (3.42 ha) of which 30 per cent was self-lease operated. In contrast, farmers in the north-east had an average farm size of 14.80 rai (2.37 ha) of which 90 per cent was self owned. This result indicates that the central region farmers hold average farm sizes larger than north-east farmers ($P < 0.01$). This is consistent with OAE (2009) and NSO (2006) who reported that farmers in the central region usually had an average farm size larger than the north-east farmers.

The results for the average net farm income between the farmers in the central and north-east regions were statistically significant at the one per cent level. This result indicated that the average net farm income of the central farmers was larger than for the north-east farmers. In 2008, the central farmers had an average net farm income of 166,445.05 baht/household, whereas the average net farm income of the north-east farmers was only 42,632.80 baht/household. As discussed in Section 4.2, the poor productivity soils, low crop yields and lack of irrigation may have caused the low net farm income of the north-east farmers.

In addition, approximately 63 per cent of the central region farmers worked off-farm, which was significant more than for the north-east farmers ($P < 0.01$). The results also showed that central farmers had significantly higher annual household incomes than north-east farmers.

Table 5.1 Household and farm characteristics of the farmers in central and north-east Thailand

Item	*Unit*	*Region*		*Overall (n=800)*	*Test of difference* [a]
		Central (n=400)	*North-east (n=400)*		
Gender	%				0.66
Male		73.3	75.8	74.5	
Female		26.8	24.3	25.5	
Age group	%				67.14***
Less than 30 years old		1.5	0.5	1.0	
31-40 years old		10.3	7.3	8.8	
41-50 years old		42.0	22.3	32.1	
51-60 years old		30.0	30.5	30.3	
Over 60 years old		16.3	39.5	27.9	
Marital status	%				12.52***
Single/Never married		4.0	2.0	3.0	
Married		87.5	86.3	86.9	
De factor relationship		0.8	4.3	2.5	
Divorced/separated		7.8	7.5	7.6	
Highest education	%				17.79***
Illiterate		3.3	2.0	2.6	
Primary school		69.5	81.8	75.6	
Secondary school		23.5	14.0	18.8	
Vocational training		2.3	0.8	1.5	
Bachelor degree		1.5	1.5	1.5	
Farming experience	%				105.69***
Less than 10 years		12.8	6.5	9.6	
11-20 years		29.3	10.0	19.6	
21-30 years		22.5	16.0	19.3	
31-40 years		19.5	22.8	21.1	
Over 40 years		16.0	44.8	30.4	
Household size	persons	4.36	4.28	4.32	-0.66
Total farm size	rai [b]	21.40	14.80	18.09	-10.10***
Land ownership status	%				168.93***
Owner-self operated		64.8	89.5	77.1	
Lease-self operated		29.3	2.0	15.6	
Tenant		0	8.5	4.3	
Other		6.0	0	3.0	
Finance farm business	%				0.15
Yes		69.3	68.0	68.6	
Average net farm income [c]	baht	166,450.05	42,632.80	104,541.42	-19.26***
Working off-farm	%				43.29***
Yes		63.3	40.0	51.6	
Annual household income	%				113.16***
Less than 10,000 baht		0	1.3	0.6	
10,001-30,000 baht		0.8	14.3	7.5	
30,001-50,000 baht		5.0	16.3	10.6	
50,001-70,000 baht		11.0	15.8	13.4	
70,001-90,000 baht		11.5	11.0	11.3	
More than 90,001 baht		71.8	41.5	56.6	

[a] Test of differences of the central and north-east household and farm characteristics based on chi-square and independent *t* test; * significant at 10%, ** significant at 5% and *** significant at 1%
[b] 1 rai = 0.16 ha.
[c] Net farm income is based on the 2008 crop year, see details in Table 6.8 and 6.9.

Source: Field survey, 2009

In terms of farmer access to credit, nearly 70 per cent of the farmers in the central and north-east regions had loans and nearly half of them borrowed from the Bank of Agriculture and Agricultural Cooperatives (BAAC). In addition, eight per cent of the farmers used their own savings to operate their farm business. Only about four per cent had loans from commercial banks. The majority of the farmers in this study obtained short-term loans (see Table 5.2). This finding supports Limsombunchai (2006), who argued that smallholder farmers in rural Thailand lacked investment funds due to a credit accessibility barrier.

Nearly 50 per cent of the farmers had small debts. Further, 30 per cent of the farmers in the north-east had outstanding debts of less than 30,000 baht during the 2008 crop year. Similarly, 27 per cent of the farmers in the central region had debts between 31,000-50,000 baht. An average of 72.6 per cent of the loans were reported to be used in operating the farm business, such as purchasing farm equipment, seeds and fertilizers, but the balance was spent on the farmer's personal and household consumption, for example, food and clothing.

Table 5.2 Financial background of the farmers in central and north-east Thailand

Item	*Region*		*Overall (n=800)*
	Central (n=400)	*North-east (n=400)*	
Sources of finance [a]			
Bank of Agriculture and Agricultural Cooperative	57.5	34.3	44.6
Cooperatives	23.7	15.9	19.4
Village funds	11.8	25.4	19.4
Personal funds	3.2	12.4	8.3
Commercial bank	6.8	0.3	3.9
Duration of credit			
Less than 1 year	65.0	72.8	68.9
Greater than 3 years	6.9	20.6	13.7
Outstanding loan debt			
Under 30,000 baht	14.4	29.4	21.9
31,000-50,000 baht	27.4	23.2	25.3
Over 91,000 baht	13.7	21.0	17.3
Average percentage of loan used			
On-farm activities	79.8	65.1	72.6
Household expenses	20.1	34.7	27.4

[a] Multiple responses

Source: Field survey, 2009

When comparing farmers in irrigated and rain-fed areas of the central and north-east regions, the survey results showed that the farmers from both areas in the two regions did not differ significantly in most characteristics (see Tables 5.3 and 5.4). The exceptions were farm size, land ownership status, net farm income and annual household income.

Average farm size was significantly different ($P < 0.01$) between the irrigated and rain-fed farmers [a] in both regions. The average farm size of the central region rain-fed farmers was 23.99 rai (3.84 ha). This is considerably larger than the average farm size of the central region irrigated farmers. Similarly, the average farm size of the north-east rain-fed and irrigated farmers was 16.29 rai (2.61 ha) and 12.75 rai (2.04 ha), respectively. This finding indicates that the farmers in rain-fed areas had larger farms than the irrigated farmers. This is probably due to agricultural land prices in irrigated areas generally being more expensive than rain-fed areas.

There also appear to be significant differences in land ownership status between the central region rain-fed and irrigated farmers. Approximately 30 per cent of the farmers in the central region irrigated areas were self-lease operated and seven per cent of them owned and leased land at the same time. Farm land rental rate was relatively high among the farmers in the irrigated areas of the central region.

The survey results showed that the average net farm income and annual household income of the irrigated farmers were significantly higher than for the rain-fed farmers in both regions. In 2008, the central region irrigated farmers had an average net farm income of 194,325.21 baht/household and over 80 per cent of them had an annual household income greater than 90,000 baht. In contrast, north-east rain-fed farmers had an average net farm income of 30,903.20 baht/household and nearly 70 per cent of them had an annual household income of less than 90,000 baht. This finding reflects a widening gap in income distribution among the smallholder farmers in the central and north-east regions of Thailand.

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[a] 'Irrigated farmers' is a short form for 'farmers owing irrigated farms' and 'rain-fed farmers' is a short form for 'farmers owing rain-fed farms' this shortened version is used to save words and space even though it is a logical nonsense.

Table 5.3 Household and farm characteristics of the Thai farmers in the central region irrigated and rain-fed areas

Item	*Unit*	*Irrigated (n=294)*	*Rain-fed (n=106)*	*Test of difference* [a]
Gender	%			1.24
Male		71.8	77.4	
Female		28.2	22.6	
Age group	%			4.84
Less than 30 years old		2.0	0	
31-40 years old		11.6	6.6	
41-50 years old		41.8	42.5	
51-60 years old		28.6	34.0	
Over 60 years old		16.0	17.0	
Marital status	%			5.82
Single/Never married		5.1	0.9	
Married		87.8	86.8	
De factor relationship		0.7	0.9	
Divorced/separated		6.5	11.3	
Highest education	%			21.58***
Illiterate		1.0	9.4	
Primary school		69.0	70.8	
Secondary school		25.2	18.9	
Vocational training		2.7	0.9	
Bachelor degree		2.0	0	
Farming experience	%			3.50
Less than 10 years		14.3	8.5	
11-20 years		28.9	30.2	
21-30 years		21.1	26.4	
31-40 years		19.0	20.8	
Over 40 years		16.7	14.2	
Household size	persons	4.45	4.11	2.05*
Total farm size	rai [b]	20.46	23.99	-3.795***
Land ownership status	%			11.61***
Owner-self operated		59.9	78.3	
Lease-self operated		33.3	17.9	
Other		6.8	3.8	
Finance farm business	%			1.89
Yes		67.3	74.5	
Average net farm income [c]	baht	194,325.21	89,135.92	10.92***
Working off-farm	%			0.90
Yes		64.6	59.4	
Annual household income	%			58.54***
Less than 10,000 baht		0	0	
10,001-30,000 baht		0	2.8	
30,001-50,000 baht		4.1	7.5	
50,001-70,000 baht		5.8	25.5	
70,001-90,000 baht		8.8	18.9	
More than 90,001 baht		81.3	45.3	

[a] Test of differences of the central region irrigated and rain-fed household and farm characteristics based on chi-square and independent *t* test; * significant at 10%, ** significant at 5% and *** significant at 1%.
[b] 1 rai = 0.16 ha
[c] Net farm income is based on the 2008 crop year, see details in Table 6.8.

Source: Field survey, 2009

Table 5.4 Household and farm characteristics of the Thai farmers in the north-east irrigated and rain-fed areas

Item	*Unit*	*Irrigated (n=168)*	*Rain-fed (n=232)*	*Test of difference* [a]
Gender	%			1.84
Male		79.2	73.3	
Female		20.8	26.7	
Age group	%			5.46
Less than 30 years old		0.0	0.9	
31-40 years old		6.0	8.2	
41-50 years old		18.5	25.0	
51-60 years old		33.9	28.0	
Over 60 years old		41.7	37.9	
Marital status	%			4.12
Single/Never married		1.2	2.6	
Married		89.9	83.6	
De factor relationship		2.4	5.6	
Divorced/separated		6.5	8.2	
Highest education	%			5.46
Illiterate		1.8	2.2	
Primary school		85.1	79.3	
Secondary school		10.7	16.4	
Vocational training		1.2	0.4	
Bachelor degree		1.2	1.7	
Farming experience	%			17.17***
Less than 10 years		2.4	9.5	
11-20 years		7.1	12.1	
21-30 years		14.3	17.2	
31-40 years		21.4	23.7	
Over 40 years		54.8	37.5	
Household size	persons	4.34	4.25	0.588
Total farm size	rai [b]	12.75	16.29	-3.74***
Land ownership status	%			1.87
Owner-self operated		87.5	90.9	
Lease-self operated		3.0	1.3	
Tenant		9.5	7.8	
Finance farm business	%			6.52**
Yes		75.0	62.9	
Average net farm income [c]	baht	58,830.81	30,903.20	6.46***
Working off-farm	%			4.45**
Yes		33.9	44.4	
Annual household income	%			20.87***
Less than 10,000 baht		0.6	1.7	
10,001-30,000 baht		8.9	18.1	
30,001-50,000 baht		11.9	19.4	
50,001-70,000 baht		15.5	15.9	
70,001-90,000 baht		9.5	12.1	
More than 90,001 baht		53.6	32.8	

[a] Test of differences of the north-east region irrigated and rain-fed household and farm characteristics based on chi-square and independent *t* test; * significant at 10%, ** significant at 5% and *** significant at 1%.
[b] 1 rai = 0.16 ha
[c] Net farm income is based on the 2008 crop year, see details in Table 6.9.

Source: Field survey, 2009

5.2 Farmers' perceptions of sources of risk and risk management strategies

As discussed in Section 4.5.3, the perceived sources of risk and risk management strategies were measured on a five point Likert scale. The scale ranges from '1' (not important) to '5' (extremely important). A list of 19 sources of risk and 16 risk management strategies were provided for the farmers' consideration in terms of how important the impact each risk source and risk management strategy was on their farming operation.

5.2.1 Sources of risk

The mean scores of each source of risk were ranked. Standard deviation (SD) was used to indicate the variation in the ratings. In addition, the independent sample t test was employed to compare mean score differences between the farmers in the central and north-east regions, including both the irrigated and rain-fed areas.

5.2.1.1 All farmer group results

Table 5.5 summarizes the results of the most important perceived sources of risk for the farmers in the central and north-east regions. The table shows that marketing risks associated with 'unexpected variability of input prices' and 'unexpected variability of product prices' were the highest and the second highest mean scores for sources of risk by the farmers in both regions. The SDs of both sources of risk in each group were less than one and this indicates that those sources of risk gained a high level of consensus among the farmers in both regions (Meuwissen et al., 2001).

The survey results showed that the uncertainty of input prices and product prices have become increasingly worrying among smallholder farmers in the central and north-east regions. As discussed in Chapter 1, this is probably due to the fact that both sources of risk are out of the farmers' control but directly affect their farm incomes. The prices of the major cash crops in Thailand, such as rice, cassava and sugarcane, are unstable; they depend on supply and demand in both local and international markets. Similarly, the average prices of the major farm inputs such as fertilizer NPK 16-20-0, which is widely used by rice farmers, fluctuated from 9,485 baht/tonne in 2006 to a peak of 19,386 baht/tonne in 2008 and then dropped to 16,199 baht/tonne in 2009 (OAE, 2009).

Table 5.5 Ranking of perceptions of sources of risk by sampled farmers in central and north-east Thailand

Source of risk	*Overall (n=800)*			*Central (n=400)*			*North-east (n=400)*			*Test of difference* [b]
	Mean [a]	*SD*	*Rank*	*Mean* [a]	*SD*	*Rank*	*Mean* [a]	*SD*	*Rank*	
Unexpected variability of input prices	4.22	0.910	*(1)*	4.09	0.901	*(1)*	4.34	0.904	*(1)*	3.92***
Unexpected variability of product prices	3.82	0.926	*(2)*	3.83	0.861	*(2)*	3.82	0.988	*(2)*	-0.11
Diseases and pests that affect plants and animals	3.52	1.153	*(3)*	3.70	1.014	*(3)*	3.34	1.252	*(6)*	-4.47***
Changes in Thailand's economic and political situation	3.48	1.080	*(4)*	3.44	0.992	*(7)*	3.53	1.161	*(3)*	1.28
Unexpected variability of yields	3.47	0.946	*(5)*	3.58	0.965	*(5)*	3.36	0.915	*(5)*	-3.35***
Changes in national government laws and policies	3.38	1.090	*(6)*	3.38	1.024	*(8)*	3.39	1.154	*(4)*	0.16
Natural disasters such as heat, fire, flood, storm	3.38	1.345	*(7)*	3.47	1.092	*(6)*	3.29	1.554	*(8)*	-1.92*
Changes in the world economic and political situation	3.30	1.097	*(8)*	3.27	1.029	*(9)*	3.32	1.161	*(7)*	0.71
Excess rainfall	3.27	1.293	*(9)*	3.59	1.017	*(4)*	2.95	1.453		-7.16***
Deficiency in rainfall causing drought	3.11	1.441	*(10)*	3.09	1.372	*(10)*	3.13	1.508	*(9)*	0.44
Problems with hired labour	3.02	1.259		2.95	1.161		3.10	1.347	*(10)*	1.72*
High level of debt	2.84	1.075		2.90	1.052		2.77	1.095		-1.75*
Accidents or problems with health	2.74	1.145		2.56	1.007		2.91	1.245		4.34***
Changes in interest rates	2.73	1.106		2.86	1.054		2.60	1.144		-3.28***
Changes in technology and breeding	2.52	1.089		2.49	0.952		2.55	1.211		0.75
Changes in land prices	2.47	1.222		2.56	1.241		2.38	1.198		-2.03**
Risk from theft	2.19	1.179		2.57	1.144		1.82	1.094		-9.44***
Changes in family situation such as marital status, inheritances, etc.	1.98	1.032		2.11	0.966		1.85	1.081		-3.52***
Being unable to meet contracting obligations	1.82	1.046		2.13	1.038		1.52	0.965		-8.50***

[a] Likert scale is used from 1 (not important) to 5 (extremely important).

[b] The mean scores of central and north-east farmers are significantly difference at *$P<0.1$, **$P<0.05$ and ***$P<0.01$ based on independent samples t test.

Source: Field survey, 2009

This finding is consistent with those of Patrick et al. (1985), Martin (1993) and Flaten et al. (2005) who argued that marketing risks associated with the variability of product and input prices were the most important sources of risk considered by the farmers in their respective study areas.

The production risks related to ‘diseases and pests affecting plants and animals’, ‘excess rainfall’ and ‘natural disasters such as floods’ were ranked third, fourth and sixth, among the farmers in the central region with mean scores of 3.70, 3.59 and 3.47, respectively. The results reflect the heavy floods that hit the central provinces during September 2008. Following this incident, 100,000 rai (16,000 ha.) of farmland in the central region were damaged (IRINNews, 2008).

Institutional risks related to ‘changes in Thailand’s economic and political situation’ and ‘changes in national government laws and policies’ were ranked third and fourth, among the north-east region farmers. This finding revealed that smallholder farmers were very concerned about the effect of the political conflicts in Thailand on their farm operation.

‘Unexpected variability of yields’ was ranked the fifth most important source of risk in both regions. In addition, the financial risks associated with ‘changes in interest rates’ and ‘high levels of debt’ were considered as ‘quite important’ by all farmers.

Sources of risk that obtained low mean scores included ‘changes in technology and breeding’, ‘changes in land prices’, ‘risk from theft’, ‘changes in the situation of farm families’ and ‘unable to meet contracting obligations’.

Comparisons of risk perception between the farmers in the central and north-east regions showed significant differences in most sources of risk. This interesting finding might be attributable to the fact that sources of risk vary depending on the farm’s geographical condition, farm type, the environmental impact and the country’s political and economic situation. Evidently, the small farm business may be affected in different ways by changes in those sources of risk.

5.2.1.2 Central region farmer group results

Table 5.6 shows ‘deficiency in rainfall causing drought’ was the most important source of risk for the farmers in the central region rain-fed areas with an average score of 4.42 and a SD of 0.755. Furthermore, the perception of drought between the farmers in central region rain-fed and irrigated areas was significantly different ($P < 0.01$). This indicates that the drought was the main specific risk that dominated the smallholder farmers’ concerns in central rain-fed areas.

The impact of marketing risks associated with ‘unexpected variability of input prices’ and ‘unexpected variability of product prices’ enormously worried the farmers in both groups. ‘Diseases and pests that affect plants and animals’ was ranked as the third and the fourth most important sources of risk among the farmers in the central region irrigated and rain-fed areas, respectively. ‘Excess rainfall’ and ‘natural disasters such as flood’ were ranked fourth and sixth in the central region irrigated areas. A possible explanation for this is because of the geographical constraint of the central region, which is a low-lying region.

‘Problems with hired labour’ is considered ‘important’ by farmers in the central region rain-fed areas. However, this source of risk is considered ‘quite important’ for the irrigated farmers. Farmers in central region rain-fed areas ranked ‘problems with hired labour’ higher than the irrigated farmers because the central region rain-fed farmers cultivated arable crops such as sugarcane, maize and sorghum, and most of these crops are labour-intensive.

‘Changes in national government laws and regulations’ and ‘changes in Thailand’s economic and political situation’ were of moderate concern among the farmers in both groups. In addition, concerns among the central region irrigated farmers regarding the financial risk associated with ‘high level of debt’ and ‘changes in interest rates’ were significantly higher than for the central region rain-fed farmers.

Table 5.6 Ranking of perceptions of sources of risk by Thai farmers in central region irrigated and rain-fed areas

Source of risk	*Irrigated (n=294)*			*Rain-fed (n=106)*			*Test of difference* [b]
	Mean [a]	*SD*	*Rank*	*Mean* [a]	*SD*	*Rank*	
Unexpected variability of input prices	4.04	0.965	*(1)*	4.25	0.673	*(2)*	-2.41**
Unexpected variability of product prices	3.89	0.877	*(2)*	3.65	0.793	*(3)*	2.56**
Diseases and pests that affect plants and animals	3.74	1.074	*(3)*	3.57	0.817	*(4)*	1.56
Excess rainfall	3.72	0.940	*(4)*	3.22	1.113	*(7)*	4.11***
Unexpected variability of yields	3.71	0.946	*(5)*	3.23	0.929	*(6)*	4.58***
Natural disasters such as heat, fire, flood, storm	3.60	1.033	*(6)*	3.10	1.171	*(9)*	3.87***
Changes in Thailand's economic and political situation	3.57	0.931	*(7)*	3.07	1.063	*(10)*	4.30***
Changes in national government laws and policies	3.48	1.001	*(8)*	3.10	1.041	*(8)*	3.19***
Changes in the world economic and political situation	3.38	0.983	*(9)*	2.97	1.099		3.35***
High level of debt	3.01	1.068	*(10)*	2.59	0.944		3.78***
Changes in interest rates	2.99	1.042		2.48	0.997		4.48***
Problems with hired labour	2.78	1.158		3.42	1.032	*(5)*	-5.37***
Changes in land prices	2.69	1.227		2.18	1.209		3.72***
Risk from theft	2.60	1.166		2.46	1.079		1.08
Deficiency in rainfall causing drought	2.60	1.215		4.42	0.755	*(1)*	-17.87***
Accidents or problems with health	2.59	1.034		2.50	0.928		0.75
Changes in technology and breeding	2.52	1.017		2.40	0.739		-0.19
Changes in family situation such as marital status, inheritances, etc.	2.13	0.979		2.05	0.930		0.75
Being unable to meet contracting obligations	2.12	1.107		2.14	0.822		1.18

[a] Likert scale is employed from 1 (not important) to 5 (extremely important).

[b] The mean scores of central region irrigated and rain-fed farmers are significantly difference at *$P<0.1$, **$P<0.05$ and ***$P<0.01$ based on independent samples *t* test.

Source: Field survey, 2009

5.2.1.3 North-east region farmer group results

Like the central region farmer group, marketing risks associated with ‘unexpected variability of input prices’ and ‘unexpected variability of product prices’ were the most important risk sources among farmers in the north-east irrigated and rain-fed groups (see Table 5.7). ‘Deficiency in rainfall causing drought’ was a major concern for the north-east region rain-fed farmers, whereas ‘excess rainfall’ and ‘natural disasters such as flood’ were considered ‘important’ by the irrigated farmers.

‘Changes in Thailand’s economic and political situation’ and ‘changes in national government laws and policies’ enormously worried among the north-east rain-fed farmers. This is because the north-east rain-fed area is one of the poorest parts of Thailand and most farmers in this area are poor. Therefore, the farmers worry about the uncertainties of government agricultural and rural development policies; changes in such policies directly impact their livelihoods and farm operation.

Production risks associated with ‘unexpected variability in yields’ was considered ‘important’ by the north-east region irrigated and rain-fed farmers (SD=0.914 and 0.917, respectively). ‘Diseases and pests that affect plants and animals’ was significantly higher for the north-east irrigated farmers than for rain-fed farmers.

The test of differences in perception of human risks associated with ‘accidents or problems with the health of the farm owners’ and ‘changes in family situation’ between the farmers in the two groups were statistically significantly ($P < 0.01$ and $P < 0.1$, respectively). North-east rain-fed farmers rated the importance of human risks higher than the north-east irrigated farmers.

Table 5.7 Ranking of perceptions of sources of risk by Thai farmers in north-east irrigated and rain-fed areas

Source of risk	*Irrigated (n=168)*			*Rain-fed (n=232)*			*Test of difference* [b]
	Mean [a]	*SD*	*Rank*	*Mean* [a]	*SD*	*Rank*	
Unexpected variability of input prices	4.35	0.909	*(1)*	4.34	0.902	*(1)*	0.05
Unexpected variability of product prices	3.86	0.924	*(2)*	3.79	1.033	*(3)*	0.68
Natural disasters such as heat, fire, flood, storm	3.84	1.424	*(3)*	2.89	1.525		6.33*
Diseases and pests that affect plants and animals	3.71	1.220	*(4)*	3.07	1.208	*(9)*	5.20*
Changes in Thailand's economic and political situation	3.47	1.168	*(5)*	3.58	1.156	*(4)*	-0.91
Excess rainfall	3.43	1.421	*(6)*	2.61	1.379		5.80*
Changes in the world economic and political situation	3.37	1.145	*(7)*	3.29	1.173	*(7)*	0.64
Changes in national government laws and policies	3.37	1.146	*(8)*	3.40	1.162	*(5)*	-0.22
Unexpected variability of yields	3.34	0.914	*(9)*	3.38	0.917	*(6)*	-0.385
Problems with hired labour	2.97	1.412	*(10)*	3.19	1.293	*(8)*	-1.62
Accidents or problems with health	2.74	1.262		3.03	1.222	*(10)*	-2.28***
High level of debt	2.65	1.022		2.86	1.140		-1.89***
Changes in technology and breeding	2.45	1.242		2.62	1.186		-1.34
Changes in interest rates	2.41	1.080		2.74	1.170		-2.88*
Deficiency in rainfall causing drought	2.22	1.429		3.79	1.189	*(2)*	-11.61*
Changes in land prices	2.15	1.172		2.55	1.191		-3.33*
Risk from theft	1.73	1.029		1.88	1.137		-1.329
Changes in family situation such as marital status, inheritances, etc.	1.68	1.050		1.97	1.089		-2.66*
Being unable to meet contracting obligations	1.44	0.971		1.58	0.959		-1.45

[a] Likert scale is employed from 1 (not important) to 5 (extremely important).

[b] The mean scores of north-east region irrigated and rain-fed farmers are significantly difference at $^{*}P$<0.1, $^{**}P$<0.05 and $^{***}P$<0.01 based on independent samples *t* test.

Source: Field survey, 2009

5.2.2 Risk management strategies

The results of the perceptions of the various risk management responses by the farmers in the central and north-east regions are discussed in this section. The mean score of each risk management response with the associated SD was calculated. The independent sample t test was used to compare the mean score differences among the groups of farmers. The farmers were asked to specify whether each risk management strategy was implemented on their small farm operations.

According to Martin (1993), Patrick et al. (1985) and Pellegrino (1999) the risk management strategies in this study can be classified into: (1) production strategies, including purchasing of farm machinery to replace labour, storing feed and/or seed reserves, applying pests and diseases programmes, having a farm reservoir for water supplies in the dry season and having diversified crop/animal or other enterprises on farm; (2) marketing strategies, including spreading sales over several time periods, obtaining market information on price forecasts and trends, selection of crop and/or animal varieties with low price variability and using forward contracts; (3) financial strategies, including holding cash and easily converted cash assets, working off-farm to supplement household income, reducing debt levels, leasing farm machinery rather than owning them and investing in non-farm businesses; and (4) miscellaneous strategies, including the ability to adjust quickly to the weather, prices and other adverse factors.

5.2.2.1 All farmer group results

Table 5.8 summarizes the results of the perceptions of risk management strategies elicited from the farmers in the central and north-east regions. Production and financial strategies were considered more important managerial responses to risk than marketing strategies by the farmers in both regions.

Among the production strategies perceived by the central region farmers, ‘purchase farm machinery to replace labour’ was the most important with an average rating of 3.45. Nearly 60 per cent of central region farmers reported using this strategy to cope with hired agricultural labour problems on their farms. From the survey, farm machinery, such as hand tractors and four-wheel tractors, was widely used among the central region farmers. This reflects the imbalance problem between agricultural and industrial labour forces in Thailand. This finding supports Ahmad and Isvilanonda (2003) who argued that the rural labour force preferred to work in the industrial sector more than in the agricultural sector due to the gap in wage rates. This may be the cause of the lack of agricultural labour especially in the central region, which has many factories located there.

‘Storing feed and/or seed reserves’ and ‘have a farm reservoir for water supplies in dry season’ showed significant differences in importance between the farmers in the central and north-east regions ($P < 0.01$). North-east farmers perceived the importance of these two production strategies higher than central region farmers. They rated ‘storing feed and/or seed reserves’ as the most important production strategies and ‘having a farm reservoir for water supplies in dry season’ was ranked third with mean ratings of 3.61 and 3.47, respectively. Over 80 per cent of the north-east farmers learned ‘storing feed and/or seed reserves’ in managing their small farm operations and approximately 65 per cent of them had experienced using the ‘having a farm reservoir for water supplies in dry season’ strategy on their farm. This indicates that the north-east farmers were confronted with the variability of input prices and severe droughts.

‘Having diversified crop, animal or other enterprises’ and ‘planting several varieties of crops’ were the least important production strategies for both groups. The north-east farmers considered these two production strategies as ‘important’ but the central region farmers rated them as ‘quite important’, which is statistically significant different ($P < 0.01$). The results indicated that the lack of farm resources may affect the diversification performance of the farmers in both groups.

Financial strategies associated with ‘holding cash and easily converted cash assets’ and ‘working off farm to supplement household income’ were considered ‘important’ by the farmers in the central and north-east regions. Approximately 60 per cent of the farmers in both regions reported that they used these two financial strategies. However, the north-east farmers perceived the importance of ‘holding cash and easily converted cash assets’ significantly higher than the central region farmers. In addition, ‘reduce debt level’ was given greater importance by the north-east farmers, whereas ‘investing in non-farm businesses’ was more important among the central region farmers. In terms of marketing strategies, north-east farmers assigned significantly greater rating scores than central region farmers to ‘obtaining market information’, ‘spread sale over several time period’ and ‘selection of crop and/or animal varieties with low price variability’.

Table 5.8 Ranking of perceptions of risk management strategies by sampled farmers in central and north-east Thailand

Risk management strategy	*Overall (n=800)*				*Central (n=400)*				*North-east (n=400)*				*Test of difference* [c]
	Mean [a]	*SD*	*%* [b]	*Rank*	*Mean* [a]	*SD*	*%* [b]	*Rank*	*Mean* [a]	*SD*	*%* [b]	*Rank*	
Production strategies:													
Purchase farm machinery to replace labour	3.44	1.086	61.6	*(1)*	3.45	1.082	58.8	*(1)*	3.43	1.092	64.5	*(5)*	-0.26
Storing feed and/or seed reserves	3.40	1.088	60.9	*(3)*	3.20	1.158	40.8	*(6)*	3.61	0.972	81.0	*(1)*	5.49^{***}
Apply pests and diseases program	3.23	1.108	53.9	*(7)*	3.26	1.103	53.8	*(4)*	3.19	1.113	54.0	*(9)*	-0.89
Have a farm reservoir	3.06	1.295	47.9	*(10)*	2.65	1.200	35.5		3.47	1.258	60.3	*(3)*	9.40^{***}
Having diversified crop, animal or other enterprises	2.94	1.126	33.4		2.84	1.118	26.0		3.05	1.126	40.8		2.65^{***}
Planting several varieties of crops	2.86	1.174	30.0		2.71	1.119	19.5		3.01	1.209	40.5		3.64^{***}
Marketing strategies:													
Obtaining market information	3.27	1.085	65.3	*(5)*	3.09	1.159	51.8	*(7)*	3.46	0.972	78.8	*(4)*	4.89^{***}
Spreading sale over several time periods	3.19	1.213	41.6	*(8)*	3.01	1.232	31.5	*(9)*	3.39	1.164	51.8	*(6)*	4.48^{***}
Selection of crop and/or animal varieties with low price variability	2.70	1.036	24.8		2.61	1.012	21.0		2.79	1.052	28.5		2.46^{**}
Use forward contracts	2.13	1.161	12.4		2.32	1.081	12.3		1.95	1.209	12.5		-4.59^{***}
Financial strategies:													
Holding cash	3.41	1.012	64.8	*(2)*	3.31	1.056	60.0	*(3)*	3.52	0.955	69.5	*(2)*	2.98^{***}
Working off farm	3.28	1.255	63.3	*(4)*	3.33	1.241	68.8	*(2)*	3.24	1.268	57.8	*(8)*	-1.07
Reduce debt level	3.27	1.042	60.0	*(6)*	3.20	1.133	48.5	*(5)*	3.33	0.940	71.5	*(7)*	1.73^{*}
Leasing farm machinery	3.13	1.085	48.9	*(9)*	3.08	1.081	38.5	*(8)*	3.17	1.089	59.3	*(10)*	1.17
Investing in non-farm businesses	2.64	1.282	31.3		2.92	1.258	42.3		2.36	1.246	20.3		-6.30^{***}
Miscellaneous strategies:													
Able to adjust quickly to weather, price and other adverse factors	3.02	0.956	42.6		2.98	0.911	42.0	*(10)*	3.06	0.998	43.3		1.18

[a] Likert scale is used from 1 (not important) to 5 (extremely important).

[b] The percentage of farmers using each risk management strategy.

[c] The mean scores of central and north-east farmers are significantly difference at $^{*}P<0.1$, $^{**}P<0.05$ and $^{***}P<0.01$ based on independent samples *t* test

Source: Field survey, 2009

‘Use forward contracts’ was the least important marketing strategy considered by most central and north-east regions farmers. Only 10 per cent of the farmers in both regions had used this strategy to manage risk. This suggests that the agricultural production under forward contracts in Thailand is still in its developmental stages and is not popular among the smallholder farmers in rural areas. However, the central region farmers perceived the importance of this marketing strategy significantly more than the north-east farmers ($P < 0.01$) with the mean scores of 2.32 and 1.95, respectively.

The perceptions of risk responses between the farmers in the central and north-east regions were statistically different in many strategies similar to their perceived sources of risk (see Table 5.8). The findings from the survey revealed that the smallholder farmers in both regions used a mix of risk strategies to manage and reduce the sources of risk they confronted. The findings support Martin (1996), who argued that the farmers’ selection criteria for risk management strategies varied depending on farm type, climatic conditions, marketing factors and agricultural rules and regulations.

5.2.2.2 Central region farmer group results

The perceptions of risk management strategies for the central region irrigated and rain-fed farmers are presented in Table 5.9. ‘Purchase farm machinery to replace labour’ was the most important production strategy considered for central region irrigated farmers. The second most important production strategy was ‘apply pests and diseases programme’ with a mean score of 3.33. This is because farmers in the central region irrigated areas have recently been confronted with diseases and pests that affected plants and animals.

Perceptions of the importance of ‘having diversified crop, animal or other enterprises’ and ‘planting several varieties of crop’ were significantly different across farmers in the central region irrigated and rain-fed areas ($P < 0.01$). Central region rain-fed farmers seemed to prefer these two strategies more than the irrigated farmers (SD=0.886 and 1.038, respectively). In addition, 50 per cent of the farmers in the central region rain-fed areas used these two strategies to manage risk on their small farms. This indicates that the central region rain-fed farmers practice higher levels of diversification than central region irrigated farmers. Ahmad & Isvilanonda (2003) identified high agricultural land prices along with increases in labour costs as the main obstacles for diversification of farming in the irrigated areas of the central region.

Table 5.9 Ranking of perceptions of risk management strategies by Thai farmers in the central region irrigated and rain-fed areas

Risk management strategy	*Irrigated (n=294)*				*Rain-fed (n=106)*				*Test of difference* [c]
	Mean [a]	*SD*	*%* [b]	*Rank*	*Mean* [a]	*SD*	*%* [b]	*Rank*	
Production strategies:									
Purchase farm machinery to replace labour	3.45	1.109	59.2	*(1)*	3.45	1.006	57.5	*(4)*	-0.06
Apply pests and diseases program	3.33	1.075	55.1	*(2)*	3.08	1.164	50.0	*(10)*	1.87*
Storing feed and/or seed reserves	3.21	1.190	40.1	*(4)*	3.15	1.067	42.5	*(8)*	0.46
Have a farm reservoir	2.62	1.156	37.4		2.75	1.317	30.2		-0.95
Having diversified crop, animal or other enterprises	2.61	1.105	19.0		3.47	0.886	45.3	*(2)*	-8.03***
Planting several varieties of crops	2.47	1.047	10.5		3.39	1.038	44.3	*(6)*	-7.78***
Marketing strategies:									
Spreading sale over several time periods	3.01	1.268	32.3	*(8)*	2.99	1.134	29.2		0.14
Obtaining market information	2.96	1.220	49.7	*(10)*	3.45	0.874	57.5	*(3)*	-4.49***
Selection of crop and/or animal varieties with low price variability	2.53	0.993	15.3		2.83	1.037	36.8		-2.55**
Use forward contracts	2.33	1.128	13.6		2.28	0.944	8.5		0.38
Financial strategies:									
Working off farm	3.33	1.278	67.3	*(3)*	3.34	1.137	72.6	*(7)*	-0.09
Holding cash	3.17	1.117	54.1	*(5)*	3.69	0.748	76.4	*(1)*	-5.31***
Reduce debt level	3.13	1.191	44.2	*(6)*	3.40	0.933	60.4	*(5)*	-2.31**
Leasing farm machinery	3.07	1.163	39.8	*(7)*	3.10	0.816	34.9	*(9)*	-0.24
Investing in non-farm businesses	2.94	1.283	42.5		2.84	1.188	41.5		0.72
Miscellaneous strategies:									
Able to adjust quickly to weather, price and other adverse factors	2.99	0.988	39.1	*(9)*	2.95	0.653	50.0		0.32

[a] Likert scale is employed from 1 (not important) to 5 (extremely important).
[b] The percentage of farmers using each risk management strategy.
[c] The mean scores of central and north-east farmers are significantly difference at $^{*}P<0.1$, $^{**}P<0.05$ and $^{***}P<0.01$ based on independent samples *t* test

Source: Field survey, 2009

Central region rain-fed farmers perceived the importance of ‘holding cash’ and ‘reduce debt level’ significantly more than the central region irrigated farmers ($P < 0.01$ and $P < 0.05$, respectively). Moreover, ‘working off-farm’ was considered ‘important’ by the farmers in both areas.

Marketing strategies associated with ‘obtaining market information’ were evaluated higher among the central region rain-fed farmers with a mean score of 3.45, which was significantly greater than the central region irrigated farmers. ‘Use of forward contracts’ was regarded as the least important marketing strategy among farmers in both areas. In addition, only 13.6 and 8.5 per cent of the central region irrigated and rain-fed farmers, respectively, had used this strategy to reduce marketing risks on their farm.

5.2.2.3 North-east region farmer group results

Table 5.10 presents the perceptions of risk management strategies elicited from the north-east irrigated and rain-fed farmers. The north-east rain-fed farmers’ responses indicated ‘having a farm reservoir for water supplies in dry season’ was the most important risk strategy with a mean score of 3.91; 70 per cent of them reported using this strategy for water supplies in the dry season. In particular, the result confirmed that severe droughts are the most important sources of risk that affect smallholder farmers in the area.

‘Storing feed and/or seed reserve’ was ranked the most important risk strategy among the north-east irrigated farmers and ranked second among the rain-fed farmers (mean score=3.60 and 3.62, respectively). Over 80 per cent of the farmers in both areas used this strategy to reduce risk. This is because most north-east farmers are poor. Thus, this production strategy is undertaken to reduce their production costs, especially for rice farmers. In addition, seed storage cottages, which were found during the field surveys, have been widely used by north-east farmers compared with the central region farmers.

Like the central region farmer results, the north-east irrigated farmers were less concerned with production strategies associated with ‘having diversified crop, animal or other enterprises’ and ‘planting several varieties of crop’ ($P < 0.1$).

‘Holding cash’ was evaluated as an ‘important’ financial strategy by the farmers in the north-east irrigated and rain-fed areas (SD=0.966 and 0.947, respectively). Other financial strategies that differed significantly between the groups of farmers included ‘reduce debt level’, ‘working off farm’ and ‘investment in non-farm businesses’.

Table 5.10 Ranking of perceptions of risk management strategies by Thai farmers in the north-east region irrigated and rain-fed areas

Risk management strategy	*Irrigated (n=168)*				*Rain-fed (n=232)*				*Test of difference* [c]
	Mean [a]	*SD*	*%* [b]	*Rank*	*Mean* [a]	*SD*	*%* [b]	*Rank*	
Production strategies:									
Storing feed and/or seed reserves	3.60	0.856	83.3	*(1)*	3.62	1.050	79.3	*(2)*	-0.27
Purchase farm machinery to replace labour	3.27	1.140	67.9	*(4)*	3.54	1.044	62.1	*(4)*	-2.50**
Apply pests and diseases program	3.18	1.085	56.5	*(8)*	3.20	1.135	52.2		-0.21
Have a farm reservoir	2.86	1.315	49.4		3.91	1.009	68.1	*(1)*	-8.96*
Having diversified crop, animal or other enterprises	2.77	1.076	35.1		3.25	1.122	44.8	*(9)*	-4.22*
Planting several varieties of crops	2.74	1.170	30.4		3.21	1.200	47.8	*(10)*	-3.93*
Marketing strategies:									
Obtaining market information	3.44	0.914	82.7	*(3)*	3.47	1.015	75.9	*(6)*	-0.30
Spreading sale over several time periods	3.19	1.110	50.0	*(7)*	3.53	1.184	53.0	*(5)*	-2.87*
Selection of crop and/or animal varieties with low price variability	2.68	0.987	31.0		2.88	1.092	26.7		-1.85***
Use forward contracts	1.80	1.159	11.9		2.05	1.235	12.9		-1.99**
Financial strategies:									
Holding cash	3.47	0.966	76.8	*(2)*	3.56	0.947	64.2	*(3)*	-0.89
Leasing farm machinery rather than owing them	3.24	1.094	69.6	*(5)*	3.11	1.083	51.7		1.30
Reduce debt level	3.24	0.904	73.8	*(6)*	3.40	0.961	69.4	*(7)*	-1.67***
Working off farm	3.02	1.292	53.0	*(9)*	3.39	1.230	61.2	*(8)*	-2.94*
Investing in non-farm businesses	2.13	1.221	20.2		2.52	1.241	20.3		-3.13*
Miscellaneous strategies:									
Able to adjust quickly to weather, price and other adverse factors	3.01	0.945	44.6	*(10)*	3.09	1.036	42.2		-0.89

[a] Likert scale is employed from 1 (not important) to 5 (extremely important).
[b] The percentage of farmers using each risk management strategy.
[c] The mean scores of central and north-east farmers are significantly difference at $^{*}P<0.1$, $^{**}P<0.05$ and $^{***}P<0.01$ based on independent samples *t* test

Source: Field survey, 2009

Marketing strategies related to ‘obtaining market information’ and ‘spreading sale over several time periods’ were considered ‘important’ by both groups of farmers with the mean scores from 3.19 to 3.53. In addition, the north-east rain-fed farmers perceived ‘selection of crop and/or animal varieties with low price variability’ significantly greater than the north-east region irrigated farmers ($P < 0.01$). ‘Use forward contracts’ was the least important marketing strategy evaluated by the farmers of both types.

5.3 Factor analysis

In this section, the results of the factor analysis of sources of risk and risk management strategies are discussed. Exploratory factor analysis with varimax orthogonal rotation was applied to the data using SPSS version 15. Exploratory factor analysis is used to reduce the number of sources of risk and risk management strategies for each group of farmers.

The Kaiser-Meyer-Oklin (KMO) value was assessed to ensure the appropriateness for factor analysis of each data set (greater than 0.6 is recommended) (Hair, 2006). A cut-off of ± 0.4 was employed for the factor loadings to determine the inter correlation among the original variables and for interpretation purposes in this study. In addition, the test of internal consistency reliability of each factor was assessed. A Cronbach’s Alpha value greater than 0.6 was suggested by Hair (2006) to yield a satisfactory result in reliability of the factor.

Subsequently, the summated scale for each factor for each group of farmers was summed and averaged depending on each factor’s structure (Hair, 2006). The summated scales were used in further analysis.

5.3.1 Sources of risk

5.3.1.1 All farmer group results

The rotated factor loadings of risk sources for all farmers in the central and north-east regions, obtained from the principal analysis and a varimax orthogonal rotation, are discussed in this section. Before conducting factor analysis, the data set adequacy measurement was assessed. The KMO value was 0.779 and the Bartlett’s Test of Sphericity achieved statistical significance ($\chi^2 = 4927.58$, $P < 0.01$), confirming that the data set was appropriate for factor analysis. However, the preliminary results indicated three sources of risk including ‘accidents or problems with health’, ‘deficiency rainfall’ and ‘changes in technology or breeding’ should be eliminated from the factor analysis because of their low communalities (< 0.40) (Hair, 2006). Following this, iteration of varimax orthogonal rotation was performed.

The results are presented in Table 5.11. Latent root criteria (eigenvalues > 1) were specified for six factors (AS1-6) from the 16 sources of risk variables for the all farmer group. These six factors can explain almost 71.2 per cent of the total variance. The Cronbach's Alpha values for factors AS1-5 in the all farmer group ranged from 0.671 to 0.899, which exceeded the minimum requirement of 0.6. This demonstrates an adequate reliability among those factors. However, the alpha value was somewhat lower (0.426) for factor AS6. Factors AS1-6 for the all farmer group can be labelled in accordance with the significant loading variables that were obtained for each factor and explained as follows:

Factor AS1: this factor is named 'economic and political' because of the relatively high loadings on the sources of risk variables with the changes in Thailand and the world economic and political situations and changes in the government laws and policies that affected the small farm operations.

Factor AS2: this factor incorporates a number of sources of risk related to the farm business environment, including risk from being unable to meet contracting obligations, problems with hired labour, theft and changes in land prices. Moreover, risk from changes in family situation (also as personal risk) loaded highly on this factor. Therefore, this factor is named 'personal and farm business environment'.

Factor AS3: this factor consists of the significant loading of 'excess rainfall' and 'natural disaster'. Factor AS3 is labelled 'natural disaster'.

Factor AS4: this factor can be interpreted as the 'financial situation' because of the high factor loadings on the changes in interest rates and high level of debt.

Factor AS5: this factor is related to the risk from unexpected variability in yields and the unpredictable product prices. Thus, this factor is classified as 'yields and product prices'.

Factor AS6: this factor is labelled 'input prices' because of the highest factor loading of the unexpected variability in input prices in this factor.

Table 5.11 Varimax rotated factor loadings of sources of risk for all sampled in Thailand farmers (n=800)

Source of risk	*Factors* [a]						*Communality*
	AS1	*AS2*	*AS3*	*AS4*	*AS5*	*AS6*	
Changes in Thailand's economic and political situation	**0.923**	0.091	0.005	0.092	0.134	0.053	0.890
Changes in the world economic and political situation	**0.875**	0.064	0.066	0.164	0.030	0.050	0.804
Changes in national government laws and policies	**0.833**	0.220	0.003	0.048	0.179	0.094	0.786
Changes in family situation	0.087	**0.748**	0.097	0.079	0.126	-0.176	0.629
Being unable to meet contracting obligations	0.009	**0.747**	0.121	0.285	0.042	-0.082	0.663
Risk from theft	0.107	**0.700**	0.078	0.203	0.151	0.108	0.583
Problems with hired labour and contractors	0.132	**0.616**	-0.170	-0.147	-0.127	0.427	0.646
Changes in land prices	0.315	**0.559**	-0.014	0.242	0.107	0.087	0.489
Excess rainfall	0.018	0.050	**0.895**	0.086	0.085	-0.039	0.821
Natural disasters	0.033	0.077	**0.862**	-0.056	-0.007	0.190	0.789
Changes in interest rates	0.119	0.261	-0.024	**0.827**	0.065	0.162	0.797
High level of debt	0.169	0.220	0.070	**0.825**	0.064	0.010	0.768
Unexpected variability of yields	0.141	0.103	0.053	0.071	**0.846**	0.017	0.755
Unexpected variability of product prices	0.131	0.122	0.033	0.046	**0.823**	0.135	0.730
Unexpected variability of input prices	0.077	-0.094	-0.014	0.064	0.115	**0.852**	0.758
Diseases and pests that affect plants and animals	0.073	0.104	0.329	0.135	0.071	**0.579**	0.483
Eigenvalues	4.35	1.83	1.71	1.22	1.21	1.07	
Per cent of total variance explained	27.17	11.46	10.70	7.61	7.55	6.69	
Cumulative per cent of the variance explained	27.17	38.63	49.33	56.95	64.49	71.19	
Cronbach's Alpha	0.889	0.743	0.776	0.763	0.671	0.426	
Number of variables	3	5	2	2	2	2	

[a] Factors AS1-6 are labelled as AS1=economic and political, AS2=personal and farm business environment, AS3=natural disaster, AS4=financial situation, AS5=yields and product prices and AS6=input prices.
'Accidents or problems with health', 'deficiency in rainfall causing drought' and 'changes in technology and breeding' are deleted from the analysis due to these sources of risk have low communalities.
Factor loadings for an absolute values greater than 0.4 are in **bold.**

Source: Field survey, 2009

5.3.1.2 Central region farmer group results

Table 5.12 presents the final results of the varimax rotated factor loadings of sources of risk for the central region farmer group. The KMO value was 0.773 with a statistically significant Bartlett's Test of Sphericity ($\chi^2 = 3513.83, P < 0.01$). In addition, based on the preliminary results, 'problems with hired labour and contractors' was removed from the factor analysis because the communality was lower than 0.4. Factor analysis was then repeated with 18 sources of risk specified.

The results in this group were similar to the all farmer group, where the factor analysis grouped the 18 sources of risk into six factors. The factors CS1-6 were named as 'personal and farm business environment', 'economic and political', 'yields and product prices', 'financial situation', 'input prices' and 'natural disaster', respectively.

In addition, these six factors identified for the central region farmer group can be explained by 72.17 per cent of the total variance. With regard to the reliability test, the Cronbach's Alpha for factors CS1-6 ranged from 0.639 to 0.884. Therefore, these factors were determined to be reliable for further analysis.

5.3.1.3 North-east region farmer group results

Table 5.13 shows the final rotated factor analysis of 15 sources of risk variables for the north-east farmer group. The KMO value was 0.747 with a statistically significant Bartlett's Test of Sphericity ($\chi^2 = 2126.24, P < 0.01$). Four sources of risk with low communalities and relatively high cross-loading problems were deleted from the factor analysis. They included 'diseases and pests that affect plants and animals', 'changes in technology and breeding', 'deficiency in rainfall causing drought' and 'being unable to meet contracting obligations'.

The factor loadings obtained from the varimax rotations grouped the 15 sources of risk into six factors for the north-east farmer group. Factor one (NS1) had three significant loading variables, factor two (NS2) had five variables, factors 3-5 (NS3-5) had two variables each and factor six (NS6) had a single component variable. The six factors explained almost 70 per cent of the total variance. The Cronbach's Alpha values for factors NS1-4 ranged from 0.675 to 0.893, which were reliable among those factors. However, the alpha value for factor NS5 had a somewhat lower reliability of 0.514. Factors NS1-6 were labelled as 'economic and political', 'personal and farm business environment', 'natural disaster', 'yields and product prices', 'financial situation' and 'input prices', respectively.

Table 5.12 Varimax rotated factor loadings of sources of risk for farmers in the central region of Thailand (n=400)

Source of risk	*Factors* [a]						*Communality*
	CS1	*CS2*	*CS3*	*CS4*	*CS5*	*CS6*	
Being unable to meet contracting obligations	**0.835**	0.129	0.004	0.164	0.076	0.026	0.747
Changes in family situation	**0.761**	0.048	0.211	0.258	-0.139	0.034	0.713
Accidents or problems with health	**0.690**	-0.108	0.020	0.244	-0.022	0.007	0.549
Changes in technology and breeding	**0.662**	0.279	-0.003	-0.173	0.062	0.289	0.634
Risk from theft	**0.553**	0.243	0.264	0.226	0.327	-0.121	0.606
Deficiency in rainfall causing drought	**0.448**	-0.043	**-0.422**	-0.386	0.350	0.193	0.690
Changes in Thailand's economic and political situation	0.047	**0.888**	0.218	0.186	0.092	-0.032	0.882
Changes in the world economic and political situation	0.065	**0.846**	0.006	0.257	-0.014	0.067	0.791
Changes in national government laws and policies	0.157	**0.797**	0.299	0.085	0.165	-0.044	0.786
Unexpected variability of yields	0.045	0.217	**0.854**	0.031	0.031	0.135	0.798
Unexpected variability of product prices	0.182	0.153	**0.793**	-0.033	0.162	0.202	0.753
Changes in interest rates	0.237	0.261	-0.050	**0.749**	0.260	0.078	0.761
High level of debt	0.343	0.348	-0.036	**0.707**	0.055	0.146	0.764
Changes in land prices	0.356	0.212	0.323	**0.497**	0.175	-0.086	0.561
Unexpected variability of input prices	-0.056	0.043	0.123	0.181	**0.809**	0.096	0.717
Diseases and pests that affect plants and animals	0.078	0.113	0.031	0.049	**0.798**	0.145	0.681
Excess rainfall	0.047	0.014	0.156	0.007	0.069	**0.880**	0.806
Natural disasters	0.073	-0.023	0.087	0.088	0.170	**0.839**	0.754
Eigenvalues	5.28	2.18	1.94	1.45	1.11	1.03	
Per cent of total variance explained	29.35	12.13	10.75	8.05	6.17	5.71	
Cumulative per cent of the variance explained	29.35	41.49	52.24	60.29	66.46	72.17	
Cronbach's Alpha	0.748	0.884	0.812	0.766	0.639	0.766	
Number of variables	6	3	2	3	2	2	

[a] Factors CS1-6 are labelled as CS1=personal and farm business environment, CS2=economic and political, CS3=yields and product prices, CS4=financial situation, CS5=input prices and CS6=natural disaster. 'Problems with hired labour and contractors' is deleted from the analysis due to this source of risk has low communalities.

Factor loadings for an absolute values greater than 0.4 are in **bold.**

Source: Field survey, 2009

Table 5.13 Varimax rotated factor loadings of sources of risk for farmers in the north-east region of Thailand (n=400)

Source of risk	*Factors* [a]						*Communality*
	NS1	*NS2*	*NS3*	*NS4*	*NS5*	*NS6*	
Changes in Thailand's economic and political situation	**0.923**	0.100	0.020	0.031	0.112	0.024	0.876
Changes in the world economic and political situation	**0.891**	0.050	0.082	0.075	0.076	0.049	0.817
Changes in national government laws and policies	**0.841**	0.200	0.001	0.072	0.121	0.039	0.770
Changes in family situation	0.048	**0.724**	0.090	0.082	0.166	-0.242	0.627
Accidents or problems with health	-0.011	**0.702**	0.097	0.076	0.055	0.159	0.537
Risk from theft	0.109	**0.658**	0.037	0.137	0.100	-0.073	0.480
Changes in land prices	0.358	**0.559**	-0.028	0.217	-0.011	-0.099	0.499
Problems with hired labour and contractors	0.179	**0.550**	-0.231	-0.014	-0.188	0.342	0.540
Excess rainfall	0.054	0.016	**0.899**	0.102	-0.006	-0.088	0.830
Natural disasters	0.036	0.081	**0.891**	-0.058	-0.022	0.126	0.822
High level of debt	0.081	0.092	0.082	**0.856**	0.086	-0.021	0.763
Changes in interest rates	0.075	0.248	-0.042	**0.823**	0.090	0.057	0.757
Unexpected variability of yields	0.100	0.054	-0.026	0.060	**0.842**	-0.029	0.727
Unexpected variability of product prices	0.144	0.112	0.001	0.104	**0.723**	0.157	0.592
Unexpected variability of input prices	0.054	-0.071	0.058	0.032	0.145	**0.910**	0.861
Eigenvalues	3.64	1.75	1.68	1.33	1.08	1.01	
Per cent of total variance explained	24.29	11.69	11.19	8.89	7.23	6.71	
Cumulative per cent of the variance explained	24.29	35.98	47.17	56.05	63.28	69.99	
Cronbach's Alpha	0.893	0.675	0.784	0.678	0.514	-	
Number variables	3	5	2	2	2	1	

[a] Factors NS1-6 are labelled as NS1=economic and political, NS2=personal and farm business environment, NS3=natural disaster, NS4=yields and product prices, NS5=financial situation and NS6=input prices.
'Diseases and pests that affect plants and animals', 'changes in technology and breeding', 'deficiency in rainfall causing drought' and 'being unable to meet contracting obligations' are deleted from the analysis due to these sources of risk have low communalities.
Factor loadings for an absolute values greater than 0.4 are in **bold.**

Source: Field survey, 2009

5.3.2 Risk management strategies

5.3.2.1 All farmer group results

Factor analysis was employed to reduce the risk strategy variables as perceived by the farmers in both the central and north-east regions. The KMO measure of data sufficiency was 0.887. In addition, Bartlett's Test of Sphericity was statistically significant at the one per cent level ($\chi^2 = 3301.16$). This indicates that the data were suitable for factor analysis.

The first iteration of factor analysis results identified the removal of 'able to adjust quickly to weather, price and other adverse factors' and 'purchase farm machinery to replace of labour', because these variables exhibited low communalities. Following this, the second rotation was performed with 14 risk strategies for the all farmer group.

The final results of the varimax rotated factor loadings for each risk strategy for this group of farmers are documented in Table 5.14. Factor analysis grouped the 14 risk management strategies into four factors. These four factors explained almost 58.33 per cent of the variance.

With regard to reliability, the Cronbach's Alpha values for factors AR1-3 were 0.742, 0.711 and 0.642, respectively. The alpha value for factor AR4 was 0.596, which is very close to the minimum cut-off level of 0.6. The factors AR1-4 can be named according to each factor structure as follows:

Factor one (AR1): this factor has a relatively high loading of the risk strategy variables related to 'apply pests and diseases programme', 'storing feed and/or seed reserves', 'have a farm reservoir for water supplies in dry season', 'spreading sale over several time period' and 'obtaining market information on prices forecast and trends'. This factor is named 'farm production and marketing management'.

Factor two (AR2): this factor is described as 'diversification' because there were significant loadings of risk strategy variables related to 'having diversified crop, animal or other enterprises', 'planting several varieties of crops' and 'selection of crop and/or animal varieties with low price variability'.

Factor three (AR3): this factor is loaded highly on 'investing in non-farm investment/business' and 'working off farm to supplement net farm income', which really represent the influence of off-farm income. Thus, factor three is named 'off-farm income'.

Factor four (AR4): this factor is interpreted as ‘financial management’, which is concerned with ‘reduce debt level’, ‘leasing farm machinery rather than owning them’ and ‘holding cash and easily converted cash assets’.

However, in factor AR3, factor analysis grouped the ‘use forward contracts’ variable, which is unrelated to the definition of this factor. Therefore, the ‘use forward contracts’ variable was deleted from factor AR3 and the Cronbach Alpha coefficient slightly improved from 0.642 to 0.697. This result illustrated that factor AR3 had a stronger internal consistency after ‘use forward contracts’ variable was deleted.

Table 5.14 Varimax rotated factor loadings of risk management strategies for all farmers sampled inThailand (n=800)

Risk management strategy	*Factors* [a]				*Communality*
	AR1	*AR2*	*AR3*	*AR4*	
Apply pests and diseases program	**0.655**	-0.035	0.318	0.047	0.533
Storing feed and/or seed reserves	**0.651**	0.162	-0.025	0.339	0.565
Have a farm reservoir for water supplies in dry season	**0.641**	0.288	0.022	0.031	0.495
Spreading sale over several time period	**0.618**	0.301	0.183	0.159	0.531
Obtaining market information on prices forecast and trends	**0.505**	0.363	0.259	0.280	0.532
Having diversified crop, animal or other enterprises	0.211	**0.796**	-0.030	0.147	0.700
Planting several varieties of crops	0.252	**0.742**	0.093	0.095	0.632
Selection of crop and/or animal varieties with low price variability	0.387	**0.505**	0.345	-0.039	0.525
Investing in non-farm investment/business	0.172	-0.001	**0.807**	0.124	0.696
Working off farm to supplement net farm income	0.341	0.058	**0.711**	0.143	0.646
Use forward contracts	-0.121	**0.441**	**0.590**	0.076	0.563
Reduce debt level	0.094	0.117	0.061	**0.787**	0.645
Leasing farm machinery rather than owning them	0.164	-0.023	0.111	**0.715**	0.551
Holding cash and easily converted cash assets	0.117	**0.440**	0.177	**0.559**	0.552
Eigenvalues	4.69	1.28	1.19	1.01	
Per cent of total variance explained	33.48	9.14	8.48	7.24	
Cumulative per cent of the variance explained	33.48	42.62	51.09	58.33	
Cronbach’s Alpha	0.742	0.711	0.642	0.596	
Number of variables	5	3	3	3	

[a] Factors AR1-4 labelled as AR1=farm production and marketing management, AR2=diversification, AR3=off-farm income and AR4=financial management.

‘Able to adjust quickly to weather, price and other adverse factors’ and ‘purchase farm machinery to replace of labour’ are deleted from the analysis due to these risk management strategies have low communalities.

Factor loadings for an absolute values greater than 0.4 are in **bold.**

Source: Field survey, 2009

5.3.2.2 Central region farmer group results

Table 5.15 summarizes the final results of the varimax rotation of risk strategy variables for the central region farmer group. The KMO was 0.891 with a statistically significant Bartlett's Test of Sphericity ($\chi^2 = 2917.15, P < 0.01$). From the first iteration of the factor analysis results, three risk strategy variables were removed due to their low communalities. They were 'holding cash and easily converted cash assets', 'obtaining market information on prices forecast and trends' and 'use forward contracts'.

The second iteration was conducted with 13 risk strategy variables and factor analysis grouped them into four factors. In addition, these four factors explained nearly 67 per cent of the total variance for this group of farmers. With regard to reliability assessment, the Cronbach's Alpha values for factors CR1-4 ranged from 0.670 to 0.790. Factor CR1 has five significant loading risk strategy variables, factor CR2 has three variables, factor CR3 has three variables and factor CR4 has two variables. The factors CR1-4 are labelled as 'farm production and marketing management', 'diversification', 'off-farm income' and 'financial management', respectively.

Factor CR3 included the variable 'apply pests and diseases programme' that was not related to the definition of this factor. Therefore, the 'apply pests and diseases programme' variable was removed. The Cronbach Alpha coefficient increased from 0.753 to 0.848 after 'apply pests and diseases programme' variable was deleted.

Table 5.15 Varimax rotated factor loadings of risk management strategies for farmers in the central region of Thailand (n=400)

Risk management strategy	*Factors* [a]				*Communality*
	CR1	*CR2*	*CR3*	*CR4*	
Purchase farm machinery to replace of labour	**0.811**	-0.046	0.069	0.108	0.677
Have a farm reservoir for water supplies in dry season	**0.601**	0.398	0.308	-0.048	0.616
Spreading sale over several time period	**0.570**	0.329	0.343	0.329	0.659
Storing feed and/or seed reserves	**0.553**	0.262	0.299	0.380	0.608
Able to adjust quickly to weather, price and other adverse factors	**0.532**	0.266	0.058	0.254	0.422
Having diversified crop, animal or other enterprises	0.123	**0.896**	0.042	0.231	0.825
Planting several varieties of crops	0.082	**0.842**	0.165	0.132	0.760
Selection of crop and/or animal varieties with low price variability	**0.423**	**0.547**	0.306	0.038	0.573
Working off farm to supplement net farm income	0.115	0.203	**0.852**	0.186	0.815
Investing in non-farm investment/business	0.162	0.175	**0.843**	0.125	0.784
Apply pests and diseases program	**0.454**	-0.043	**0.530**	0.138	0.508
Reduce debt level	0.221	0.131	0.054	**0.824**	0.749
Leasing farm machinery rather than owning them	0.105	0.156	0.276	**0.774**	0.711
Eigenvalues	5.35	1.28	1.07	1.00	
Per cent of total variance explained	41.15	9.86	8.25	7.70	
Cumulative per cent of the variance explained	41.16	51.01	59.26	66.97	
Cronbach's Alpha	0.792	0.776	0.753	0.670	
Number of variables	5	3	3	2	

[a] Factors CR1-4 labelled as CR1=farm production and marketing management, CR2=diversification, CR3=off-farm income and CR4=financial management.

'Holding cash and easily converted cash assets', 'obtaining market information on prices forecast and trends' and 'use forward contracts' are deleted from the analysis due to these risk management strategies have low communalities.

Factor loadings for an absolute values greater than 0.4 are in **bold.**

Source: Field survey, 2009

5.3.2.3 North-east region farmer group results

Table 5.16 presents the varimax rotated factor loadings of risk management strategies for the north-east farmer group. The KMO was 0.826 with a statistically significant Bartlett's Test of Sphericity ($\chi^2 = 995.38, P < 0.01$). The first rotated of results deleted 'have a farm reservoir for water supplies in dry season' and 'spreading sale over several time period' because of their low communalities. Following this, the second rotation was performed.

Factor analysis grouped the 14 risk strategy variables for the north-east farmer group into four factors, which explained almost 51 per cent of the variance. Factor one (NR1) is labelled, because of its structure as 'preventative strategies'. This factor has high loadings of the risk strategy variables 'obtaining market information on prices forecast and trends', 'apply pests and diseases programme', 'able to adjust quickly to weather, price and other adverse factors' and 'holding cash and easily converted cash assets'. These strategies are used to protect production and reduce marketing and financial risks.

Factor two (NR2) consists of the significant loading risk strategy variables associated with 'investing in non-farm investment/business', 'working off farm to supplement net farm income', 'use forward contracts' and 'selection of crop and/or animal varieties with low price variability'. This factor is labelled as 'off-farm income and marketing management' to best describe the dimensionality of the data. Factors three (NR3) and four (NR4) are interpreted as 'diversification' and 'financial management', respectively.

Regarding the reliability measurement, factors NR1-3 have Cronbach's Alpha values that achieved the minimum acceptable level of reliability. However, the alpha coefficient for factor NR4 was 0.226. This finding may have resulted from the proportion of variables in this factor exhibiting multidimensionality (Yu, 2001). Therefore, the 'financial management' factor was excluded from further analysis because it was inconsistent and had a high level of error variance.

Table 5.16 Varimax rotated factor loadings of risk management strategies for farmers in the north-east region of Thailand (n=400)

Risk management strategy	*Factors* [a]				*Communality*
	NR1	*NR2*	*NR3*	*NR4*	
Obtaining market information on prices forecast and trends	**0.715**	0.025	0.211	0.105	0.567
Apply pests and diseases program	**0.662**	0.155	0.170	0.028	0.492
Able to adjust quickly to weather, price and other adverse factors	**0.605**	0.288	-0.125	-0.276	0.541
Holding cash and easily converted cash assets	**0.574**	0.100	0.192	0.393	0.530
Investing in non-farm investment/business	0.071	**0.684**	-0.002	0.189	0.509
Use forward contracts	0.090	**0.679**	-0.095	-0.023	0.479
Working off farm to supplement net farm income	0.198	**0.636**	0.198	0.104	0.494
Selection of crop and/or animal varieties with low price variability	0.377	**0.479**	0.328	-0.161	0.505
Having diversified crop, animal or other enterprises	0.212	-0.068	**0.750**	-0.058	0.615
Planting several varieties of crops	0.268	0.243	**0.612**	-0.028	0.506
Storing feed and/or seed reserves	0.013	-0.133	**0.584**	0.275	0.435
Purchase farm machinery to replace of labour	0.017	0.434	**0.568**	-0.004	0.511
Reduce debt level	0.133	0.078	-0.013	**0.679**	0.486
Leasing farm machinery rather than owning them	-0.070	0.065	0.048	**0.674**	0.466
Eigenvalues	3.41	1.46	1.25	1.03	
Per cent of total variance explained	24.32	10.40	8.89	7.35	
Cumulative per cent of the variance explained	24.32	34.72	43.62	50.97	
Cronbach's Alpha	0.611	0.613	0.588	0.226	
Number of variables	4	4	4	2	

[a] Factors NR1-4 labelled as NR1=preventive strategies, NR2=off-farm income and marketing management, NR3=diversification, and NR4=financial management.

'Have a farm reservoir for water supplies in dry season' and 'spreading sale over several time period' are deleted from the analysis due to these risk management strategies have low communalities.

Factor loadings for an absolute values greater than 0.4 are in **bold.**

Source: Field survey, 2009

5.4 The association between the farmers' characteristics and source of risk and management perception of risks

Multiple regression analysis was employed to investigate the relationship between the farmers' socioeconomic characteristics and the perceptions of sources of risk and risk management strategy components obtained from the factor analysis. The summated scales of sources of risk and risk strategy factors of each group of farmers were summed up and averaged based on the relevant variables in each factor structure and their internal consistency.

Before performing multiple regression analysis, all models were assessed for normality, linearity, multicollinearity and homoscedasticity to ensure the appropriateness of the equations (Pallant, 2007). Pearson correlation coefficients of the farmers' perceptions of sources of risk and risk management strategies with socioeconomic variables are shown in Appendix B.

The results in this section are divided into two parts. In the first part, the association between the farmers' perceptions of sources of risk and the socioeconomic characteristics of each group of farmers are discussed. In the next part, the influences of the farmers' characteristics on risk management responses are investigated.

5.4.1 Sources of risk

5.4.1.1 All farmer group results

Table 5.17 shows the relationship between all farmers' socioeconomic status and the different perceptions of sources of risk components. Models 1-4 are statistically significant at the one per cent level. However, the coefficients of determination (R^2) of most of the models are low. This result is consistent with the findings of Flaten et al. (2005) and Meuwissen et al. (2001) who found low explanatory power of regression models between the perceptions of sources of risk and risk strategies with the farmers' characteristics. Both sets of authors argued that the lower R^2 of the regression models implies that the farmers' perceptions of sources of risk and risk strategies differed from farmer to farmer.

Gender is negatively related to the 'personal and farm business environment' and 'natural disaster' risks on farm. This implies that female heads of farm households are likely to perceive these sources of risk as significantly more important than male household heads. Similarly, the age of farmers and farm size are negatively related to the 'natural disaster' risk, which means young farmers and farmers who have smaller farm sizes tended to perceive ‘natural disaster’ as a higher on-farm source of risk. This finding may be attributable to the severe floods across Thailand in 2008.

The highest educational level is positively related to the ‘personal and farm business environment’ risk, which indicates that more educated farmers perceived this source of risk as significantly more important in farming. The reason may be due to the more educated farmers having found that the family farm situation and the changes in farm business environment, such as high labour wages and relatively high prices of agricultural land, may indirectly affect their farm operations.

The number of years in farming experience is negatively related to the ‘economic and political’ risk perceptions. However, the annual household income and the size of farm household exhibited a positive relationship with this source of risk. This result suggests that less experienced farmers, farmers who have higher annual household income and farmers with larger household size tended to perceive risk related to ‘economic and political’ as highly important. This finding may have resulted from the instability of Thailand political situation since September 2006.

Farm business finance is positively related to the ‘financial situations’ risk factor and is statistically significant at the one per cent level. This suggests that farmers who have loans are more likely to pay more attention to the changes to their farm financial situation, such as interest rates and level of debts. In addition, farm business finance is positively related to the ‘natural disaster’ risk factor. This implies that farmers who have loans perceived this source of risk as highly important. This may be due to the ‘natural disaster’ risk damaging their farm crops, which results in insecurity of their farm income and debt repayment capacity.

Risks related to the ‘economic and political’ and ‘personal and farm business environment’ were perceived as highly important by farmers who had off-farm work. This suggests that farmers who have off-farm work are very concerned about those risks that can disrupt their off-farm income.

With regard to the farm location variable, the regression result showed a strong relationship with more than half of the risk factors. Farmers in the central region tended to perceive the ‘personal and farm business environment’, ‘natural disaster’ and ‘financial situation’ as more important risk factors than north-east farmers; north-east farmers are more concerned about ‘economic and political’ risk. This finding indicates that the sources of risk on small-holding farms differ significantly between these two regions.

Table 5.17 Multivariate regression of the source of risk components and household and farm characteristics of all sampled Thai farmers (n=800) [a]

Independent variables	*Risk source components* [b]					
	AS1	*AS2*	*AS3*	*AS4*	*AS5*	*AS6*
Constant	3.170***	1.943***	3.287***	2.466***	3.619***	3.887***
Age [c]	-0.039	-0.079	-0.306**	-0.056	-0.118	-0.110
Gender [d]	-0.024	-0.199***	-0.182*	-0.063	-0.056	0.040
Highest education [e]	0.068	0.233***	0.123	0.122	0.123	-0.015
Farming experiences [f]	-0.139*	0.024	0.134	-0.098	0.013	0.102
Off-farm work [g]	0.135*	0.281***	0.037	0.067	0.092	0.057
Farm size	-0.003	0.005	-0.011**	-0.004	0.001	-0.007*
Net farm income	-2.37E-07	-9.81E-07***	1.35E-06**	-6.90E-07	-2.77E07	-2.78E-07
Farm location [h]	-0.166*	0.301***	0.313***	0.196**	0.079	0.138*
Finance farm business [i]	0.028	-0.038	0.294***	0.408***	0.027	0.083
Annual household income [j]	0.231***	0.068	0.009	0.130	0.100	0.044
Household size	0.063***	0.051***	0.008	0.023	0.001	-0.006
R^2	0.034***	0.124***	0.064***	0.061***	0.021	0.015

[a] Variables and models significant at $^{*}P<0.1$, $^{**}P<0.05$ and $^{***}P<0.01$;
[b] Factors AS1-6 are labelled as AS1=economic and political, AS2=personal and farm business environment, AS3=natural disaster, AS4=financial situation, AS5=yields and product prices and AS6=input prices;
[c] 1, if the farmer's age over 40 years old, 0 otherwise;
[d] 1, if the farmer is male, 0 if female;
[e] 1, if the highest education of the farmer is high school and higher, 0 if primary school education or less;
[f] 1, if the farming experience over 30 years, 0 otherwise;
[g] 1, if the farmer has off-farm work, 0 if no off-farm work;
[h] 1, if farmer's farm is located in central region, 0 if a farm located in north-east region;
[i] 1, if farm has a loan, 0 if farm without a loan; and
[j] 1, if household income greater than 90,001 baht and 0 represent otherwise.

Source: Field survey, 2009

5.4.1.2 Central region farmer group results

Table 5.18 presents the relationships of the sources of risk and the central region farmers' characteristics. Models 1-6 exhibited a low R^2, but all models are statistically significant. The farming experience variable did not show any significant association with any source of risk component.

Female household heads in the central region perceived 'personal and farm business environment' and 'natural disaster' as important sources of risk. The 'personal and farm business environment' risk was perceived as more important by the more educated central region farmers.

Except for the 'economic and political' risk, the off-farm work coefficient shows a positive significant association with the sources of risk. This suggests that central region farmers who have off-farm work exhibited more anxiety about the risks that can affect their overall household income. Similarly, net farm income was negatively related to the sources of risk

CS1-4. This implies that central region farmers who have lower net farm incomes tend to perceive these sources of risk as highly important.

Central region farmers with larger farms were highly concerned about the ‘yields and product prices’ risk. The reason may be due to the farming conditions in the central region, which is concentrated with rice and cash crops. Thus, changes in yields and product prices lead to the instability of farm income, especially for farmers with large farms.

Table 5.18 Multivariate regression of the source of risk components and household and farm characteristics of the Thai central region farmers (n=400) [a]

Independent variables	*Risk source components* [b]					
	CS1	*CS2*	*CS3*	*CS4*	*CS5*	*CS6*
Constant	2.368***	2.987***	3.602***	2.338***	4.212***	3.731***
Age [c]	-0.075	-0.002	-0.164	-0.021	-0.205	-0.091
Gender [d]	-0.214***	-0.135	-0.104	0.031	-0.089	-0.291***
Highest education [e]	0.201**	0.139	0.111	0.114	0.007	0.099
Farming experiences [f]	-0.026	0.106	0.073	0.150	-0.018	-0.042
Off-farm work [g]	0.250***	0.151	0.186**	0.222**	0.203**	0.304***
Farm size	-0.003	0.005	0.020***	0.003	-0.011	-0.002
Net farm income	-7.14E-07*	-1.39E06**	-1.59E-06***	-2.44E06***	-2.73E-07	3.29E-07
Farm location [h]	0.246**	-0.421***	-0.486***	-0.581***	0.048	-0.519***
Finance farm business [i]	0.041	-0.070	-0.160*	0.156	0.139	0.182*
Annual household income [j]	0.033	0.287**	0.144	0.352***	0.010	-0.282**
Household size	0.048**	0.089***	0.029	0.080***	-0.010	0.020
R^2	0.142***	0.117***	0.105***	0.163**	0.057**	0.134***

[a] Variables and models significant at *P<0.1, **P<0.05 and ***P<0.01;
[b] Factors CS1-6 are labelled as CS1=personal and farm business environment, CS2=economic and political, CS3=yields and product prices, CS4=financial situation, CS5=input prices and CS6=natural disaster;
[c] 1, if the farmer’s age over 40 years old, 0 otherwise;
[d] 1, if the farmer is male, 0 if female;
[e] 1, if the highest education of the farmer is high school and higher, 0 if primary school education or less;
[f] 1, if the farming experience over 30 years, 0 otherwise;
[g] 1, if the farmer has off-farm work, 0 if no off-farm work;
[h] 1, if the farmer’s farm is located in central region rain-fed areas, 0 if a farm located in irrigated areas;
[i] 1, if farm has a loan, 0 if farm without a loan; and
[j] 1, if household income greater than 90,001 baht and 0 represent otherwise.

Source: Field survey, 2009

The farm location coefficient negatively related to ‘economic and political’, ‘yields and production prices’, ‘financial status’ and ‘natural disaster’ risks. This implies that central region irrigated farmers tended to perceive these sources of risk as more important than the central region rain-fed farmers. However, the farmers in the central region rain-fed areas are more concerned with the ‘personal and farm business environment’ risk.

The central region farmers with larger households tended to perceive sources of risk related to the ‘personal and farm business environment’, ‘economic and political’ and ‘financial situation’ as highly important. Larger annual household income farmers in the central region perceived the ‘economic and political’ and ‘financial situation’ risk as highly important. However, they perceived the ‘natural disaster’ risk as less important.

5.4.1.3 North-east region farmer group results

Multiple regression results for the sources of risk components and socioeconomic variables of the north-east farmers are shown in Table 5.19. The R^2 of models 1-4 are statistically significant and explained about 10 per cent of the total variance. There are five socioeconomic variables, age, farming experience, off-farm work, farm location and finance farm business, which have statistically significant associations with at least one source of risk for north-east farmers.

Age is negatively related to ‘natural disaster’ risk. The young north-east farmers perceived this risk factor as more important than older farmers. The north-east farmers who have off-farm work and the farmers who have larger net farm income perceived ‘personal and farm business’ as a highly important source of risk.

Risks associated with ‘economic and political’ and ‘yields and product prices’ were perceived as much less relevant by the more experienced north-east farmers. This may be because these sources of risk caused fluctuations in farm income. Therefore, less-experienced farmers worried more about these sources of risk.

The farm location coefficient was negatively related to the ‘natural disaster’ risk factor. This suggests that north-east irrigated farmers’ perceived ‘natural disaster’ as more important than north-east rain-fed farmers. The reason may be because some areas in the north-east irrigated lowland were severely damaged by the severe floods in 2008. In contrast, north-east rain-fed farmers scored highly on the ‘personal and farm business environment’ and ‘yields and production prices’ risk factors.

The farm business finance coefficient was positively related to ‘natural disaster’ and ‘yields and product prices’. This means that farmers who had loans were more concerned about those risk factors that affect their debt repayment capacity.

Table 5.19 Multivariate regression of the source of risk components and household and farm characteristics of the north-east Thai farmers (n=400) [a]

Independent variables	*Risk source components [b]*					
	NS1	*NS2*	*NS3*	*NS4*	*NS5*	*NS6*
Constant	3.146***	2.189***	3.939***	2.457***	3.545***	3.799***
Age [c]	0.130	-0.008	-0.567**	-0.013	0.132	0.252
Gender [d]	0.175	-0.100	-0.117	-0.103	0.094	0.046
Highest education [e]	-0.111	0.131	0.076	0.123	0.016	0.037
Farming experiences [f]	-0.430***	0.015	0.225	-0.254**	-0.110	0.191*
Off-farm work [g]	0.128	0.164*	-0.124	0.020	0.041	-0.065
Farm size	0.002	0.002	0.011	0.001	0.005	-0.002
Net farm income	7.14E-07	2.05E-06*	6.55E-07	8.94E-07	-1.65E-06	4.41E-07
Farm location [h]	0.007	0.275***	-0.895***	0.285**	-0.082	0.096
Finance farm business [i]	0.161	0.092	0.291**	0.632***	0.204**	0.024
Annual household income [j]	0.049	-0.119	-0.178	-0.122	-0.055	0.170
Household size	0.019	-0.019	-0.029	-0.032	-0.038	0.007
R^2	0.052**	0.055**	0.134***	0.137***	0.036	0.036

[a] Variables and models significant at $^{*}P$<0.1, $^{**}P$<0.05 and $^{***}P$<0.01;
[b] Factors NS1-6 are labelled as NS1=economic and political, NS2=personal and farm business environment, NS3=natural disaster, NS4=yields and product prices, NS5=financial situation and NS6=input prices;
[c] 1, if the farmer's age over 40 years old, 0 otherwise;
[d] 1, if farmer is male, 0 if female;
[e] 1, if the highest education of the farmer is high school and higher, 0 if primary school education or less;
[f] 1, if the farming experience over 30 years, 0 otherwise;
[g] 1, if the farmer has off-farm work, 0 if no off-farm work;
[h] 1, if the farmer's farm is located in north-east region rain-fed areas, 0 if a farm located in irrigated areas;
[i] 1, if farm has a loan, 0 if farm without a loan; and
[j] 1, if household income greater than 90,001 baht and 0 represent otherwise.

Source: Field survey, 2009

5.4.2 Risk management strategies

5.4.2.1 All farmer group results

Table 5.20 summarizes the multiple regression models of the risk management strategy components and the socioeconomic variables for all farmers. The goodness-of-fit coefficients of all models were rather low, except for model three where the coefficient explained around 27 per cent of the variation of the dependent variable. Models 1-4 are statistically significant ($P < 0.01$). The age variable is insignificant in relation to the risk strategy components of all farmers.

Gender was negatively related to 'off-farm income', which means that female household heads perceived this risk strategy as more important than male household heads. The reason is because the female farmers or wives can easily find off-farm work, such as weaving and/or handicrafts that are widely found throughout the north-east, to supplement their household income.

The highest educational level was positively related to the ‘farm production and marketing management’, ‘diversification’ and ‘off-farm income’ risk strategies. This implies the more educated farmers perceived these risk management strategies as highly important. This finding is similar to that of Mustafa (2006) who argued that the more educated farmers performed better in managing their farm business compared with less educated farmers.

The length of farming experience was negatively related to the ‘farm production and marketing management’, ‘diversification’ and ‘financial management’ risk strategies. This suggests that less experienced farmers were more likely to be interested in employing these strategies to manage risk on their farms than the more experienced farmers.

Off-farm work was positively related to all four risk strategy components. These relationships may be due to the farmers who have off-farm work to enhancing their farm income; they are willing to adopt such strategies to improve and maintain their farm income. Similarly, the net farm income coefficient shows a negative relationship with all four risk strategy components. This suggests that the farmers who have a lower net farm income believe that these risk strategies can help to increase their farm income.

Farm size was positively related to the ‘diversification’ strategy. Farmers with larger farms perceived a diversification strategy as highly important. It should be noted that farm size is one of the constraints to diversification, that is, farmers with a small holding have limited ability to diversify their farm activities (Ahmad & Isvilanonda, 2003).

Farmers who had higher annual household incomes perceived the ‘financial management’ strategy as highly important. In contrast, they perceived the ‘diversification’ strategy as less important than farmers who had lower annual income. In addition, risk management strategies related to ‘farm production and marketing management’ and ‘off-farm income’ were perceived as less important by the farmers who had loans. Farmers with larger households perceived ‘farm production and marketing management’ as slightly more important than smaller household farmers.

The farm location coefficient was negatively related to ‘farm production and marketing management’, ‘diversification’ and ‘financial management’ risk strategies. This may imply that farmers in the north-east perceived these risk strategies as more important than the central region farmers. This is because most north-east farmers are poorer.

Table 5.20 Multivariate regression of the risk strategy components and household and farm characteristics of all sampled Thai farmers (n=800) [a]

Independent variables	*Risk strategy components* [b]			
	AR1	*AR2*	*AR3*	*AR4*
Constant	3.310***	2.956***	2.523***	3.428***
Age [c]	0.054	0.124	0.003	-0.002
Gender [d]	-0.019	-0.107	-0.136*	-0.047
Highest education [e]	0.258***	0.167**	0.378***	0.110
Farming experiences [f]	-0.132**	-0.238***	-0.100	-0.121*
Off-farm work [g]	0.249***	0.227***	0.944***	0.150**
Farm size	0.001	0.015***	0.003	-0.004
Net farm income	-1.11E-06***	-1.98E-06***	-7.67E-07*	-7.32E-07**
Farm location [h]	-0.383***	-0.143*	0.092	-0.160**
Finance farm business [i]	-0.126**	-0.039	-0.202***	-0.026
Annual household income [j]	0.023	-0.275***	0.054	0.158**
Household size	0.033*	0.002	0.026	-0.001
R^2	0.146***	0.138***	0.267***	0.053***

[a] Variables and models significant at *P<0.1, **P<0.05 and ***P<0.01;
[b] Factors AR1-4 are labelled as AR1=farm production and marketing management, AR2=diversification, AR3=off-farm income and AR4=financial management;
[c] 1, if the farmer's age over 40 years old, 0 otherwise;
[d] 1, if farmer is male, 0 if female;
[e] 1, if the highest education of the farmer is high school and higher, 0 if primary school education or less;
[f] 1, if the farming experience over 30 years, 0 otherwise;
[g] 1, if the farmer has off-farm work, 0 if no off-farm work;
[h] 1, if the farmer's farm is located in central region, 0 if a farm located in north-east region;
[i] 1, if farm has a loan, 0 if farm without a loan; and
[j] 1, if household income greater than 90,001 baht and 0 represent otherwise.

Source: Field survey, 2009

5.4.2.2 Central region farmer group results

Table 5.21 shows the regression coefficients between the risk strategy components and the central region farmers' socioeconomic variables. All models are statistically significant at the one per cent level but model four is weak with R^2 of about 0.084. All socioeconomic variables, excluding age, farming experience and farm business finance, exhibited a statistically significant association with at least one risk strategy component of the central region farmers.

The female household heads in the central region perceived the 'diversification' and 'off-farm income' risk strategies as highly important. In addition, the more educated central region farmers tended to perceive risk strategies related to 'farm production and marketing management', 'diversification' and 'off-farm income' as highly important. Central region farmers with off-farm work perceived all four risk strategies as more important than farmers with no off-farm work.

The farm location coefficient was positively related to the 'diversification' and 'financial management' risk strategies. This implies that the central region rain-fed farmers tended to perceive these strategies as highly important. This finding supports Ahmad and Isvilanonda (2003) who argued that the central region rain-fed farmers tended to show high levels of diversification.

Central region farmers who had higher net farm income tended to recognise the 'farm production and marketing management' risk strategy as less important. Moreover, the 'diversification' strategy was perceived as less important by central region farmers who had higher annual household incomes. Risk strategies related to 'farm production and marketing management' and 'off-farm income' were perceived as highly important by the larger household farmers.

Table 5.21 Multivariate regression of the risk strategy components and household and farm characteristics of the Thai central region farmers (n=400) [a]

Independent variables	*Risk strategy components [b]*			
	CR1	*CR2*	*CR3*	*CR4*
Constant	2.945***	3.064***	2.539***	3.424***
Age [c]	-0.138	-0.066	-0.026	-0.241
Gender [d]	-0.087	-0.179**	-0.254**	-0.130
Highest education [e]	0.210**	0.197**	0.481***	0.117
Farming experiences [f]	0.018	-0.110	0.128	-0.085
Off-farm work [g]	0.330***	0.260***	1.155***	0.197*
Farm size	0.003	-0.010	-0.002	-0.017
Net farm income	-1.28E-06***	-4.09E-07	-5.01E-07	5.82E-08
Farm location [h]	-0.099	0.624***	0.012	0.362***
Finance farm business [i]	-0.076	-0.085	-0.175	-0.115
Annual household income [j]	-0.118	-0.330***	-0.152	0.248
Household size	0.076***	0.018	0.055*	0.015
R^2	0.139***	0.257***	0.350***	0.084***

[a] Variables and models significant at *P<0.1, **P<0.05 and ***P<0.01;
[b] Factors CR1-4 are labelled as CR1=farm production and marketing management, CR2=diversification, CR3=off-farm income and CR4=financial management;
[c] 1, if the farmer's age over 40 years old, 0 otherwise;
[d] 1, if farmer is male, 0 if female;
[e] 1, if the highest education of the farmer is high school and higher, 0 if primary school education or less;
[f] 1, if the farming experience over 30 years, 0 otherwise;
[g] 1, if the farmer has off-farm work, 0 if no off-farm work;
[h] 1, if the farmer's farm is located in central region rain-fed areas, 0 if a farm located in irrigated areas;
[i] 1, if farm has a loan, 0 if farm without a loan; and
[j] 1, if household income greater than 90,001 baht and 0 represent otherwise.

Source: Field survey, 2009

5.4.2.3 North-east region farmer group results

Table 5.22 shows the regression coefficients between the risk strategy components and the north-east farmers' socioeconomic variables. Model two can explain nearly 20 per cent of the variation in the dependent variable. However, the R^2 of models one and three are low (see Table 5.22). All three models are statistically significant at the one per cent level.

Age of household head was positively related to 'diversification'. This implies that the older north-east farmers perceived this risk strategy as more important than younger farmers. The more educated north-east farmers attached high scores to the 'off-farm income and marketing management' strategy. Farming experience had a significant negative relationship with all risk strategy components of the north-east farmers. This suggests that less experienced farmers were more concerned with risk management on their farms. In addition, farmers with off-farm work perceived 'off-farm income and marketing management' as highly important.

The north-east rain-fed farmers perceived the importance of 'off-farm income and marketing management' and 'diversification' as greater than the north-east irrigated farmers. This is due to the difference in the nature of farming under the two conditions. In the north-east irrigated area, the farmers, in general, were involved with intensive rice production. Therefore, they were less concerned about diversification strategies.

Table 5.22 Multivariate regression of the risk strategy components and household and farm characteristics of the north-east Thai farmers (n=400) [a]

Independent variables	*Risk strategy components* [b]		
	NR1	*NR2*	*NR3*
Constant	3.149***	2.391***	2.815***
Age [c]	0.220	0.118	0.338**
Gender [d]	0.103	-0.021	0.015
Highest education [e]	0.146	0.190*	-0.064
Farming experiences [f]	-0.308***	-0.355***	-0.352***
Off-farm work [g]	0.079	0.447***	0.128
Farm size	-0.003	-2.71E-05	-0.002
Net farm income	1.77E-06*	8.41E-07	2.02E-06*
Farm location [h]	0.085	0.227**	0.330***
Finance farm business [i]	-0.042	-0.159*	0.044
Annual HH income [j]	0.121	0.138	0.012
Household size	-0.018	0.003	0.010
R^2	0.087***	0.194***	0.107***

[a] Variables and models significant at $^{*}P<0.1$, $^{**}P<0.05$ and $^{***}P<0.01$;
[b] Factors NR1-3 are labelled as NR1=preventive strategies, NR2=off-farm income and marketing management, NR3=diversification;
[c] 1, if the farmer's age over 40 years old, 0 otherwise;
[d] 1, if the farmer is male, 0 if female;
[e] 1, if the highest education of the farmer is high school and higher, 0 if primary school education or less;
[f] 1, if the farming experience over 30 years, 0 otherwise;
[g] 1, if the farmer has off-farm work, 0 if no off-farm work;
[h] 1, if the farmer's farm is located in north-east region rain-fed areas, 0 if a farm located in irrigated areas;
[i] 1, if farm has a loan, 0 if farm without a loan; and
[j] 1, if household income greater than 90,001 baht and 0 represent otherwise.

Source: Field survey, 2009

5.5 Summary of findings

In summary, the perceptions of sources of risk and risk management strategies were different between farmers in the central and north-east regions and also between farmers in rain-fed and irrigated areas. The farmers' perceptions of sources of risk showed that the marketing risk associated with 'unexpected variability of input prices' and 'unexpected variability of product prices' were perceived as the most important sources of risk for all smallholder farmers in the central and north-east regions. The analysis of the perceptions of sources of risk indicated that 'deficiency in rainfall causing drought' was a major concern among the rain-fed farmers of both regions, whereas irrigated farmers were more concerned about 'diseases and pests that affect plants and animals' and 'natural disaster such as flood'.

Production and financial risk management strategies were of major concern to smallholder farmers in both regions. 'Purchase farm machinery to replace labour' and 'working off farm' were determined as the most important risk management strategies for the central region farmers, whereas north-east farmers put more emphasis on ‘storing feed and/or seed reserves’ and ‘holding cash’.

The study used factor analysis to group and reduces the number of sources of risk and risk management strategy variables into a smaller set of components. The factor analysis of sources of risk variables of the central region farmers produced the following components: CS1=personal and farm business environment, CS2=economic and political, CS3=yields and product prices, CS4=financial situation, CS5=input prices and CS6=natural disaster. The sources of risk components for the north-east farmers were NS1=economic and political, NS2=personal and farm business environment, NS3=natural disaster, NS4=yields and product prices, NS5=financial situation and NS6=input prices.

In terms of risk management strategy, factor analysis grouped risk strategy variables for farmers in the central region into the following components: CR1=farm production and marketing management, CR2=diversification, CR3=off-farm income and CR4=financial management. The risk strategy components for the north-east farmers comprised NR1=preventive strategies, NR2=off-farm income and marketing management, NR3=diversification, and NR4=financial management.

The relationships between the socio-economic characteristics and the perceptions of sources of risk and risk strategy components of farmers in the central and north-east regions were investigated using multiple regression analysis. The results indicated that some socio-economic variables had a statistically significant impact on the perceptions of the source of risk and risk strategy components of the farmers in both regions. However, the explanatory power (R^2) of most of the investigated models was low. The results also indicated that the perceptions of sources of risk and risk management strategies were individual and revealed the perceived differences between the central and north-east region farmers. This is because each farmer has had different experiences regarding sources of risk and responded in different ways to cope with the risks, depending on farm type, geographical location of farm, economic and political situation.

Chapter 6
Stochastic Risk Efficiency Analysis - Results and Discussion

This chapter analyses the stochastic risk efficiency of the alternative farming systems in the central and north-east regions. This chapter is divided in five sections. The results of the farmers' absolute risk aversion coefficients derived from alternative utility functions are described in Section 6.1. Section 6.2 analyses the whole-farm net income among the different farming systems, as elicited from the farmers in both regions. The stochastic efficiency analysis of each farming system is then assessed and ranked in Section 6.3. Section 6.4 discusses the sensitivity analysis results. The last section summarizes the findings.

6.1 Farmers' absolute risk aversion coefficients

The results in this section are divided into two parts. The results relating to the measurement of the absolute risk aversion coefficients ($r_a(w)$) of the farmers in the central and north-east regions are described in the first part. In the second part, the relationships between the $r_a(w)$ and farmers' socioeconomic characteristics are investigated and discussed.

6.1.1 Measurement of the absolute risk aversion coefficients

As discussed in Section 4.5.4, individual certainty equivalent (CE) values elicited from the farmers using the ELCE method were employed to derive the each farmer's utility function. The alternatives between a lottery ticket with a 50:50 chance of winning either 100,000 baht or zero and a sure sum of money were offered to the farmers in several different scenarios until a series of nine CE values, in accordance with nine utility values, were obtained for each farmer.

In addition, a comparison between different utility functional forms was examined to find the best fit for the sequence of data points elicited from each farmer, using the nonlinear least square (NLS) method. The general form of the alternative utility functions, which comprise the cubic function, negative exponential function, power function and expo-power function, and the $r_a(w)$ estimation for each functional form are presented in Table 4.5.

Two hundred and seven central region farmers and 228 north-east farmers were then incorporated into the $r_a(w)$ estimation. This is due to the sufficiency of the sequence of data points elicited from the ELCE method. Therefore, a total of 828 and 912 equations, respectively, were estimated using four different utility functions (four equations for each farmer). The summary of the individual estimated parameters and R^2 for the equations categorized by four utility functional forms are documented in Appendix C. Full details of the $r_a(w)$ estimated by four different functional forms for each farmer are also documented.

The R^2 of all equations estimated by the four utility functional forms are significant at the 10 per cent level, based on the F-statistic. When comparing the average R^2 estimated across the four utility functions, the cubic function provided the highest average R^2 of 0.985 and 0.986 for the central and north-east farmers, respectively, whereas the negative exponential function provided the lowest average R^2 values of 0.926 and 0.930, respectively (see Tables C.1 and C.2 in Appendix C).

However, in terms of the significance of the individual parameters, a number of the utility functions parameters were statistically insignificant based on the t-statistic (a, b, c and d parameters for the cubic function; α and β parameters for the power function and β parameter for the expo-power function). This problem is similar to previous studies relating the choice of utility function to the classification of risk preferences (see Binici et al., 2003; Torkamani & Haji-Rahimi, 2001). Binici et al. (2003) revealed that this problem may result from the use of small numbers of observations to estimate each equation. The authors also argued that when the curve-fitting test is carried out, the statistical significance of the equation, R^2, is more likely to be important than the significance of the individual parameter.

Furthermore, care should be taken when interpreting the results from the power and expo-power functions regarding the fit of the parameters' restrictions. For the power function, there are 25 equations among the central region farmer group and 40 equations among the north-east farmer group that a parameter restriction ($0 < \gamma < 1$) is violated. Similarly, with 85 and 54 equations of the central and north-east farmer groups using the expo-power function, a parameter restriction ($\gamma > 1$) is violated.

The estimated parameters, subsequently, are used to evaluate the farmers' risk attitudes. A summary of the maximum and minimum ranges of the $r_a(w)$ derived by each utility function for the central and north-east farmers is shown in Tables 6.1 and 6.2.

The results of this study strongly support the findings of Ramaratnam et al. (1986), Zuhair et al. (1992) and Binici et al. (2003), who pointed out that the choice of utility functional form directly influenced the classification of the farmers' risk preferences (see Table C.3 and C.4 for full details). For example, farmer 577 is classified as risk averse when assessed by the negative exponential and expo-power utility functions, whereas for the cubic and power utility functions this farmer has risk preferring behaviour. This implies that one farmer, perhaps, can be classified as risk averse by one utility functional form and risk loving when another utility functional form is employed. Consequently, the choice of utility function is important because it can reveal opposite risk preferences.

Based on the central region farmer group results, the negative exponential and expo-power functions categorized all farmers as risk averse. The $r_a(w)$ given by the negative exponential function ranged from 0.0000144 to 0.0001330, which is exactly the same as the range of $r_a(w)$ estimated by the expo-power function. The cubic function generates a range of $r_a(w)$ from -0.0004612 to 0.0010622. At the income midpoint, the cubic function classified 106 central region farmers as risk averse, whereas 101 farmers had a risk preferring attitudes. Moreover, the $r_a(w)$ given by the power function ranged from -0.0000098 to 0.0000135. One hundred and eighty-five central region farmers were classified as risk averse and 22 farmers as risk loving at the income midpoint.

Table 6.1 Summary of the absolute risk aversion coefficients evaluated by four different utility functional forms using information acquired from the Thai central region farmers

Summary	*Absolute risk aversion coefficients*			
	Cubic function	*Negative exponential function*	*Power function*	*Expo-power function*
Range:				
Minimum	-0.0004612	0.0000144	-0.0000098	0.0000046
Maximum	0.0010622	0.0001330	0.0000135	0.0001571
Mean	-0.0000016	0.0000300	0.0000062	0.0000373
Standard deviation	0.0001062	0.0000137	0.0000049	0.0000259
Number of farmer's utility functions estimated	207	207	207	207
Number of farmers were classified as risk averse	106	207	185	207
Number of farmers were classified as risk preferring	101	0	22	0

Note: The $r_a(w)$ for cubic, power and expo-power utility functions are estimated at the midpoints of the ranges of income used for eliciting each farmer's utility function. The $r_a(w)$ for the negative exponential utility function is independent at any level of income.

Table 6.2 Summary of the absolute risk aversion coefficients evaluated for four different utility functional forms using information acquired from the north-east Thai farmers

Summary	*Absolute risk aversion coefficients*			
	Cubic function	*Negative exponential function*	*Power function*	*Expo-power function*
Range:				
Minimum	-0.0033131	0.0000109	-0.0000110	-0.0000005
Maximum	0.0012670	0.0012450	0.0000174	0.0030196
Mean	-0.0000042	0.0000345	0.0000051	0.0000399
Standard deviation	0.0002477	0.0000831	0.0000056	0.0001998
Number of farmer's utility functions estimated	228	228	228	228
Number of farmers were classified as risk averse	126	228	189	227
Number of farmers were classified as risk preferring	102	0	39	1

Note: The $r_a(w)$ for cubic, power and expo-power utility functions are estimated at the midpoints of the ranges of income used for eliciting each farmer's utility function. The $r_a(w)$ for the negative exponential utility function is independent at any level of income.

The negative exponential function classified most of the 228 farmers in the north-east as risk averse. The $r_a(w)$ varied from 0.0000109, the least risk averse, to 0.0012450, the most risk averse. The cubic function exhibited a wide range of $r_a(w)$, from -0.0033131 to 0.0012670. This functional form classified 126 farmers as risk averse and 102 as risk preferring. The power function classified 189 north-east farmers as risk averse and 39 farmers as risk loving, the $r_a(w)$ ranged from -0.0000110 to 0.0000174. Most north-east farmers were classified as risk averse when estimated by the expo-power function, with only one farmer classified as risk loving. The $r_a(w)$ given by the expo-power function ranged from -0.0000005 to 0.0030196.

The independent sample t-test was conducted to investigate the differences in the $r_a(w)$ values obtained from the four different utility functions for the central and north-east farmer groups (see Table C.5). The comparative results suggested that the $r_a(w)$ derived from the cubic, negative exponential and expo-power functions were not significantly different between both groups of farmers, but the $r_a(w)$ given by the power function is statistically significant at the 10 per cent level. Therefore, it is reasonable to conclude that the risk preferences among the smallholder farmers in both regions are similar.

As noted by Musser et al. (1984), the interpretation of risk preferences derived by different functional forms must be considered carefully. Therefore, the negative exponential appeared to be the best utility function to describe the observed farmers' risk preferences in this study compared with the other three utility functions. This is because the results obtained from the negative exponential function did not violate either the parameter restriction or the statistical criteria. This finding is consistent with Ramaratnam et al. (1986) and Zuhair et al. (1992) who emphasized that the negative exponential function performed better than other functional forms in explaining the producers' risk behaviour in their study. Therefore, the relevant ranges of the $r_a(w)$ derived from the negative exponential utility function for the central and north-east farmers will be incorporated into the stochastic efficiency analysis in Section 6.3.

Unfortunately, the consistency in the levels of $r_a(w)$ obtained from this study cannot be compared with other studies because there is a lack of up-to-date evidence pertaining to risk preferences assessment among Thailand's farmers. However, Grisley and Kellog (1987) provided an empirical evaluation of the partial relative risk aversion of farmers in northern Thailand using an experimental method, which was similar to Binswanger's (1980) study. The authors' results indicated that all farmers were risk averse.

In addition, the $r_a(w)$ estimation could vary depending on the process employed to elicit the utility function, geographical zone and the selection of functional form to predict $r_a(w)$ (Binici et al., 2003). The results of $r_a(w)$ obtained from the negative exponential utility function in this study are quite close to Zuhair et al.'s (1992) results among Sri Lanka farmers; their $r_a(w)$ ranged from 0.0000161 to 0.0035684. In a recent study, Nartea and Webster (2008) employed a similar magnitude of the $r_a(w)$, derived from the negative exponential function, as a suggested guideline to classify New Zealand farmers' attitudes towards risk.

6.1.2 Influence of farmers' characteristics on the absolute risk aversion coefficients

This section discusses the impact of the socioeconomic characteristics on the variation in risk preferences. A multiple regression analysis was conducted to investigate the possible relationships between risk coefficients and the personal characteristics within each group of farmers. As discussed in Section 4.5.5, the six socioeconomic variables of farmer's age, gender, education level, size of household, farm size and net farm income were employed to correlate with the $r_a(w)$ obtained from the negative exponential function for the central and north-east region farmers.

The principal measure for violations of the basic assumptions of the regression analysis was examined (Pallant, 2007). The results showed no major problems with either model. The Pearson correlation coefficients of $r_a(w)$ and the socioeconomic variables of both regression models are documented in Appendix D.

Table 6.3 presents the estimated regression results for $r_a(w)$ and the socioeconomic variables of the central and north-east region farmer groups. The R^2 of both regression models is statistically significant ($P < 0.05$), and explained roughly six per cent of the total variance. The results for the central region farmer group indicated that highest education level had a negative significant relationship with $r_a(w)$. This implies that the less educated central region farmers tended to exhibit more risk-averse behaviour. This result is similar to Moscardi and Janvry's (1977) and Binswanger's (1980) findings.

The household size of central region farmers had a significantly negative relationship with $r_a(w)$. This suggests that central region farmers with smaller households are likely to be more risk averse than the larger household farmers. The finding is consistent with Moscardi and Janvry (1977) who argued that farmers become less risk averse as family size increases. The authors also indicated that this maybe because the larger household size is associated with increasing availability of agricultural and off-farm labour. Therefore, it could enhance the potential to generate more household income and increased risk seeking behaviour.

Table 6.3 Multivariate regression of the absolute risk aversion coefficients and socioeconomic variables of Thai central and north-east farmers

Independent variables	*Regression coefficients* [a]	
	Central farmer group	*North-east farmer group*
Constant	3.73E-05***	7.42E-05***
Age [b]	8.59E-07	-5.10E-05***
Gender [c]	-3.19E-07	-8.02E-07
Highest education [d]	-5.47E-06**	2.17E-05
Household size	-1.51E-06**	-6.35E-07
Farm size	2.33E-08	-1.27E-07
Net farm income	-2.50E-12	1.60E-10
R^2	0.066**	0.055**

[a] Variables and models significant at *P<0.1, **P<0.05 and ***P<0.01;
[b] 1, if the farmer age over 40 years old, 0 otherwise;
[c] 1, if the farmer is male, 0 if female; and
[d] 1, if the highest education of the farmer is high school and higher, 0 if primary school education or less.

Source: Field survey, 2009

For north-east farmers, only the farmer's age variable showed a negative significant relationship with $r_a(w)$. That is, younger north-east farmers tended to have a higher risk aversion. This finding contrasts with Moscardi and Janvry (1977), Lins, Gabriel and Sonka (1981) and Gómez-Limón et al. (2003) who argued that younger generation farmers would be less risk averse than the older generation. However, Shahabuddin et al. (1986) showed a negative relationship between a farmer's age and the risk aversion of the farmers in their study. This is because most north-east farmers are poor. Therefore, even though the farmers are young and potential express a high acceptance of risk, but most of the farmers preferred stability rather than deal with risk and income variability.

Unfortunately, the impact of the gender variable on $r_a(w)$ was insignificant in both regression models. Therefore, the results of this study could not indicate whether women or men farmers were more willing to assume risk. However, Binswanger (1980) showed a negative relationship between gender and risk aversion among the Indian farmers, which indicated that women farmers were less willing to assume risk than men. This study showed a weak relationship between the net farm income variable, which is associated with wealth of the farmers, and $r_a(w)$ in both groups of farmers. This finding is similar to Binswanger's (1980) result, which showed wealth did not impact on risk aversion significantly.

Despite both regression models not yielding satisfactory results in terms of predictive power, it can be concluded that the characteristics of risk aversion among smallholder farmers in central and north-east Thailand can be explained by their non-wealth socioeconomic variables.

6.2 Analysis of annual net farm income for alternative farming systems

This section discusses the results from the sampled farmers in central and north-east regions of the annual net farm income of the different farming systems. The returns and production costs for each farming system are based on the information from the 2008 crop year. The results in this section are reported in two parts. The physical characteristics of the different farming systems and their rotations in the central and north-east regions are provided in the first part. In the second part, the calculation and analysis of the annual net farm income for the different farming systems using the whole-farm income model (as discussed in Section 4.5.2) are estimated.

6.2.1 Cropping patterns

6.2.1.1 Central region

Table 6.4 shows details of the different farming systems practised by the sampled smallholder farmers in the central region rain-fed and irrigated areas. The results showed that field crop-based production is the most important farming system for farmers in the central region rain-fed area. Rice-intensive production is a significant farm activity among the different farming systems for central region irrigated farmers. The average total farm size for the different farming systems in the central region and their rotations are documented in Table 6.5.

The results showed that cassava, sugarcane, maize and sorghum were important field crops produced by the farmers in the central region rain-fed area. More than 70 per cent of the central region rain-fed farmers have experience growing large scale monoculture crops. The study revealed the four different farming systems commonly practised among the farmers in the central region rain-fed area are:

CRFP1 *Cassava*: the farmers planted cassava during May and harvested it about 10-11 months later, in February-March. Approximately 17 per cent of the central region rain-fed farmers apply this farming system, with an average cultivated area around 21.44 rais.

CRFP2 *Sugarcane*: approximately 41 per cent of the central region rain-fed farmers cultivate sugarcane, with an average area around 25 rais. Sugarcane is a long-duration field crops that is generally planted at the end of rainy season (December-January) and harvested during November-December.

CRFP3 *Maize*: this is a single crop of maize produce by around 17 per cent of the central region rain-fed farmers with an average cultivated area of approximately 26.22 rais. The farmers usually grow maize before the rainy season begins, during May-June, and harvest it in September.

CRFP4 *Maize → sorghum*: the mixed crops of maize and sorghum fit this farming system well. About 22 per cent of the central region rain-fed farmers grow sorghum in the dry season after the maize harvest (September-December). The average area used for growing maize and sorghum are 21.24 and 21.67 rais, respectively.

Conversely, a multiple lowland rice cropping pattern was widely practised among the central region irrigated farmers. Around 80 per cent of the central region irrigated farmers cultivated wet rice followed by one crop of dry rice (CIFP1). Around 17 per cent of them practised three lowland rice crops annually (CIFP2). This is because the central region irrigated area is the largest commercial rice cultivated area of Thailand. In CIFP1, wet rice is generally planted during June-July and harvested in December, after which dry rice is cultivated. However, in the CIFP2 system intensive rice production is practised. The central region rain-fed farmers have reduced the period of wet rice cultivation to nearly four months (July-October). The first crop of dry rice is planted in October and harvested in March and this is followed by the second crop during March to July.

Table 6.4 Different farming systems produced by the Thai central region farmers (n=400)

Farming system	*Irrigated area*		*Rain-fed area*	
	Number of farmers	*%*	*Number of farmers*	*%*
CRFP1: *Cassava*	-	-	18	17.0
CRFP2: *Sugarcane*	-	-	43	40.6
CRFP3: *Maize*	-	-	18	17.0
CRFP4: *Maize → sorghum*	-	-	23	21.7
CIFP1: *WSR → DSR I*	233	79.2	-	-
CIFP2: *WSR → DSR I → DSR II*	50	17.0	-	-
Others	11	3.8	4	3.8
Total	294	100	106	100

Note: WSR=wet rice; DSR I=first crop of dry rice; and DSRII=second crop of dry rice.

Source: Field survey, 2009

6.2.1.2 North-east region

The different farming systems and their rotations for the sampled farmers in the north-east region are summarized in Tables 6.6 and 6.7. The study showed that multiple cropping between rice and different upland field crops is the main cropping pattern for the farmers in rain-fed agriculture of the north-east. Wet rice, cassava and sugarcane are the most important cash crops. A single crop of wet rice can be found in the severe drought zone of this region. However, about 35 per cent of the farmers in the north-east rain-fed area have a multiple crop pattern. North-east rain-fed farmers divide their available land and other production resources to cultivate wet rice together with cassava or sugarcane to enhance their farm income. In addition, integrated crop-livestock farming systems are becoming popular among the farmers here. Around 30 per cent of the north-east rain-fed farmers produce crops and possess small numbers of livestock, especially cattle. The six different farming systems in north-east region rain-fed areas are:

NRFP1 *Wet rice*: following seasonal drought problems, around 30 per cent of the north-east rain-fed farmers grow only a single crop of rice a year, in the rainy season from June to November. The average area for this type of farming is relatively small (around 9 rais).

Table 6.5 Average farm size and rotations for the different farming systems in the central region of Thailand for the year 2008

Farming system	*Average total area (rai)*	*Average effective area for each individual crop activity (rai)*	*Cropping rotations* *Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Rain-fed area														
CRFP1: *Cassava*	21.44	21.44					Cassava	Cassava	Cassava	Cassava	Cassava	Cassava	Cassava	Cassava
CRFP2: *Sugarcane*	25.23	24.93	Sugarcane	Sugarcane	Sugarcane	Sugarcane	Sugarcane	Sugarcane	Sugarcane	Sugarcane	Sugarcane	Sugarcane	Sugarcane	
CRFP3: *Maize*	26.22	26.22					Maize	Maize	Maize	Maize	Maize			
CRFP4: *Maize → sorghum*	21.67	21.24/21.67					Maize	Maize	Maize	Maize	Sorghum	Sorghum	Sorghum	Sorghum
Irrigated area														
CIFP1: *WSR → DSR I*	20.50	20.45/20.48	DSR I	DSR I	DSR I				WSR	WSR	WSR	WSR	WSR	
CIFP2: *WSR → DSR I → DSR II*	21.90	21.82/21.82/21.58			DSR II	DSR II	DSR II	DSR II	WSR	WSR	WSR	WSR	DSR I	DSR I

Note: 1 rai = 0.16 ha.
WSR=wet rice; DSR I=first crop of dry rice; and DSRII=second crop of dry rice

Source: Field survey, 2009

Generally, this farming system is used by farmers in severe drought areas without irrigation where other crops could not grow during the dry season.

NRFP2 *Wet rice + cassava*: in this farming system, around 23 per cent of the north-east rain-fed farmers separated their land to grow wet rice and cassava. Wet rice is cultivated in June and harvested in late November, whereas cassava is planted before the rainy season begins (during April-May) and harvested from March to April. The average farm size is around 18.33 rais and the land allocated for wet rice and cassava is around 8.97 and 9.31 rais, on average, respectively.

NRFP3 *Wet rice + sugarcane*: wet rice and sugarcane is the main combination of crops for this farming system. Similar to NRFP2, rice is grown in the rainy season, during June to November. Sugarcane is planted during November and harvested between 11-12 months later. The average farm size is approximately 21.14 rais. The average effective area used for growing rice and sugarcane is 8.52 and 11.21 rais, respectively.

NRFP4 *Wet rice with cattle*: around 23 per cent of the north-east rain-fed farmers applied this crop-livestock farming system. The farmers grow one crop of rice during the rainy season and have small herds of domesticated cattle. Raising free-range cattle is generally practised among farmers in this region and rice straw is use as cattle feed. The average area under cultivation is 16 rais and the average number of cattle sold during 2008 was 1.91 head.

NRFP5 *Wet rice + cassava with cattle*: approximately five per cent of north-east rain-fed farmers cultivated multiple crops of rice and cassava and also owned cattle. The average farm size is around 21 rais. About 10.2 rais is used to produce rice and another 10.8 rais to grow cassava. In addition, in 2008, an average of 1.2 head of live cattle was sold to the local market by the farmers.

NRFP6 *Wet rice + sugarcane with cattle*: in this farming system, the farmers allocated an average of 9 rais to grow rice and 9.57 rais for growing sugarcane. In 2008, an average of 1.42 head of cattle was sold. However, this farming system was used by only three per cent of the surveyed north-east rain-fed farmers.

For the north-east irrigated area, the results showed that wet rice followed by dry rice (NIFP1) was the primary cropping pattern. Around 60 per cent of the north-east irrigated farmers cultivated wet rice during June to November, and dry rice is planted in January and harvested in late April. The average farm size is approximately 13 rais. The two crops of rice, together with tomatoes (NIFP2), were planted by five per cent of the north-east irrigated farmers. Tomatoes are usually planted in a small area of approximately 0.58 rai after the rainy season and harvested in April. In addition, approximately 21 per cent of the north-east irrigated farmers have a crop-livestock farming system, growing two rice crops and raising cattle (NIFP3). On average, 1.01 head of cattle was sold from this farming system.

Table 6.6 Different farming systems produced by the north-east Thai farmers (n=400)

Farming system	*Irrigated area*		*Rain-fed area*	
	Number of farmers	*%*	*Number of farmers*	*%*
NRFP1: *WSR*	-	-	70	30.2
NRFP2: *WSR + cassava*	-	-	54	23.3
NRFP3: *WSR + sugarcane*	-	-	29	12.5
NRFP4 [a]: *WSR with cattle*	-	-	54	23.3
NRFP5 [a]: *WSR + cassava with cattle*	-	-	10	4.3
NRFP6 [a]: *WSR + sugarcane with cattle*	-	-	7	3.0
NIFP1: *WSR → DSR I*	96	57.1	-	-
NIFP2: *WSR → DSR I + tomato*	9	5.4	-	-
NIFP3 [a]: *WSR → DSR I with cattle*	35	20.8	-	-
Others	28	16.7	8	3.5
Total	168	100	232	100

Note: WSR=wet rice; and DSR I=first crop of dry rice
[a] Crop-livestock farming system

Source: Field survey, 2009

6.2.2 Annual net farm income

The structure of returns and costs of production estimated using the whole-farm income model for alternative farming systems practised by the smallholder farmers in the central and north-east regions in the 2008 crop year are discussed in this section. The average yields and prices of the individual crops and livestock used to generate the total farm income and the variable and fixed costs of each farming system are documented in Appendix E.

The expenses of the different farming systems in this study were measured for three major production process costs. The details of each process are: (1) land preparation cost including the labour costs, cost of hired machinery, cost of maintenance and fuel costs; (2) planting cost consists of labour costs for planting, seeds, fertilisers, pesticides, herbicides, weeding, spraying and irrigation service fee; and (3) harvesting cost such as wages for harvesting, loading and transportation. In addition, feed cost is considered in the crop-livestock farming systems.

Table 6.7 Average farm size and rotations for the different farming systems in the north-east region of Thailand for the year 2008

<table>
<tr><th rowspan="2">Farming system</th><th rowspan="2">Average total area (rai)</th><th rowspan="2">Average effective area for each individual crop activity (rai)</th><th rowspan="2">Average cattle sold (head)</th><th colspan="12">Cropping rotations</th></tr>
<tr><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td colspan="16"><u>Rain-fed area</u></td></tr>
<tr><td>NRFP1:
WSR</td><td>10.11</td><td>9.09</td><td>-</td><td colspan="5"></td><td colspan="6">WSR</td><td></td></tr>
<tr><td>NRFP2:</td><td>18.33</td><td>8.97/9.31</td><td>-</td><td colspan="5"></td><td colspan="6">WSR</td><td></td></tr>
<tr><td>WSR + cassava</td><td></td><td></td><td></td><td colspan="4"></td><td colspan="8">Cassava</td></tr>
<tr><td>NRFP3:</td><td>21.14</td><td>8.52/11.21</td><td>-</td><td colspan="5"></td><td colspan="6">WSR</td><td></td></tr>
<tr><td>WSR + sugarcane</td><td></td><td></td><td></td><td colspan="9"></td><td></td><td colspan="2">Sugarcane</td></tr>
<tr><td>NRFP4[a]:
WSR with cattle</td><td>17.98</td><td>15.97</td><td>1.91</td><td colspan="5"></td><td colspan="6">WSR</td><td></td></tr>
<tr><td>NRFP5[a]:</td><td>21.00</td><td>10.20/10.80</td><td>1.20</td><td colspan="5"></td><td colspan="6">WSR</td><td></td></tr>
<tr><td>WSR + cassava with cattle</td><td></td><td></td><td></td><td colspan="4"></td><td colspan="8">Cassava</td></tr>
<tr><td>NRFP6[a]:</td><td>20.28</td><td>9.00/9.57</td><td>1.42</td><td colspan="5"></td><td colspan="6">WSR</td><td></td></tr>
<tr><td>WSR + sugarcane with cattle</td><td></td><td></td><td></td><td colspan="9"></td><td></td><td colspan="2">Sugarcane</td></tr>
<tr><td colspan="16"><u>Irrigated area</u></td></tr>
<tr><td>NIFP1:
WSR → DSR I</td><td>13.33</td><td>12.55/12.77</td><td>-</td><td colspan="4">DSR I</td><td></td><td colspan="6">WSR</td><td></td></tr>
<tr><td>NIFP2:</td><td>12.83</td><td>10.33/10.11/ 0.58</td><td>-</td><td colspan="4">DSR I</td><td></td><td colspan="6">WSR</td><td></td></tr>
<tr><td>WSR → DSR I + tomato</td><td></td><td></td><td></td><td colspan="3">Tomato</td><td colspan="8"></td><td></td></tr>
<tr><td>NIFP3[a]:
WSR → DSR I with cattle</td><td>9.82</td><td>8.88/8.84</td><td>1.01</td><td colspan="4">DSR I</td><td></td><td colspan="6">WSR</td><td></td></tr>
</table>

Note: 1 rai = 0.16 ha.

WSR=Wet rice; and DSR I=First crop of dry rice

[a] Crop-livestock farming system

Source: Field survey, 2009

The fixed cost calculations include agricultural land tax, rent and depreciation of farm assets. This study revealed Thailand government charges agricultural land use taxes to farmers at a low rate (approximately 4 to 10 baht per rai). Moreover, in some areas of the north-east the government provides a land tax exemption scheme for smallholder farmers who owned land areas less than 5 rais (0.8 ha.).

With regard to the annual depreciation estimation, the straight-line method without salvage value was employed. McConnell and Dillon (1997) pointed out that this depreciation method is efficient and best suited to small farms in Asian countries because most of the farm asset values experienced little impact from external obsolescence. Therefore, the fixed cost for farm buildings, machinery and vehicles used for farm activities were included as part of the annual depreciation analysis in this study.

6.2.2.1 Central region

Table 6.8 summarises the returns and costs for the different farming systems in the central region. In the central region rain-fed area, the results showed that sugarcane production (CRFP2) generated the highest annual gross farm income, which amounted to approximately 300,000 baht. This is nearly three times greater than the total farm income earned from cassava (CRFP1). The CRFP4 (maize followed by sorghum) system generated gross farm income of 129,465 baht, which is a little higher than maize production (CRFP3).

Regarding farm expenditure, sugarcane production (CRFP2) had the highest production costs of the different farming systems. This is because sugarcane is a labour-intensive crop. Labour is hired for either hand-planting or hand harvesting activities. Therefore, wage costs would probably have influenced the increased expenses of sugarcane production (see Table E.1 in Appendix E). The total variable cost of sugarcane production is 155,916 baht, whereas, for the other farming systems, expenses varied from 40,000 to 50,000 baht. Regarding the fixed expenditure, the results show fixed costs represented a small proportion of the total production costs, contributing approximately 10 per cent for all farming systems in this area.

The results for the central region irrigated area showed the three rice crop production (CIFP2) system generated the highest gross farm income. CIFP2 produced an annual gross farm income of around 500,000 baht, but the total expenses of this farming system were over 200,000 baht. Most of the expenses were associated with the large chemical fertilizer costs and the cost of hired farm machinery, use for either land preparation or harvesting. Moreover, it was reported that nearly half of fixed expenditure from farming systems in the central region irrigated area were spent on rent (see Table E.2). This may due to the increased demand for agricultural land in the area (Ahmad & Isvilanonda, 2003).

Therefore, we can conclude that the increase in intensity of rice crops is associated with an increase in annual gross farm income for the farmers in the central region irrigated area. The results also showed that crop yields, product prices and the area under cultivation are major factors that directly influence the differences in annual gross farm income among the different farming systems in central region rain-fed area.

Moreover, it can be assumed that farm production in the central region is transforming into intensive agriculture. There are two reasons for this transformation. First, farm machinery (such as four-wheel tractors, hand tractors and combine harvesters) has been widely used among the sampled central region farmers in an attempt to replace increasingly expensive hired labour. Second, the excessive application of chemical fertilizer to maintain high crop yields, especially for the irrigated rice farmers, not only resulted in increased costs of production but also caused soil pollution and environmental changes.

Table 6.8 Average net farm income of each farming system in central Thailand, 2008 year price levels (n=400)

Farming system	*Average (baht)*				
	Total farm income [a]	*Total variable cost* [a]	*Gross margin*	*Total fixed cost* [a]	*Net farm income*
		Rain-fed area			
CRFP1: *Cassava*	93,288.67	40,194.44	53,094.22	4,604.64	48,489.58
CRFP2: *Sugarcane*	303,690.93	155,916.28	147,774.65	17,677.19	130,097.46
CRFP3: *Maize*	111,126.11	45,179.44	65,946.67	8,121.91	57,824.76
CRFP4: *Maize → sorghum*	129,465.43	49,839.78	79,625.65	8,223.83	71,401.82
All rain-fed area farms	192,796.24	91,966.93	100,829.30	11,693.38	89,135.92
		Irrigated area			
CIFP1: *WSR → DSR I*	323,650.99	126,535.07	197,115.92	14,527.37	182,588.55
CIFP2: *WSR → DSR I → DSR II*	505,186.00	206,474.00	298,712.00	15,983.14	282,728.86
All irrigated area farms	345,607.76	136,832.89	208,774.86	14,449.65	194,325.21
All central region farms	305,112.70	124,943.42	180,169.29	13,719.24	166,450.05

Note: WSR=wet rice; DSR I=first crop of dry rice; and DSRII=second crop of dry rice
[a] See more details in Tables E.1 and E.2 in Appendix E

Source: Field survey, 2009

6.2.2.2 North-east region

For the north-east rain-fed area, the results showed that the single crop of wet rice (NRFP1) produced the lowest annual gross farm income, 27,496 baht. The annual gross farm income generated by the multiple cropping systems, NRFP2 and NRFP3, were 62,147 and 110,038 baht, respectively. Integrated crop and livestock farming systems (NRFP4-6) also provided the farmers with relatively high gross farm incomes (see Table 6.9). It is noticeable from the results that the increase in gross farm income of the north-east rain-fed farmers was due to increased farm diversification. In addition, variations in gross farm income among the different farming systems under rain-fed production may have resulted from the wide fluctuations in agricultural productivity, caused by either the irregularity of annual rainfall or poor soil fertility (Grandstaff, Grandstaff, Limpinuntana, & Suphanchaimat, 2008; Ng, 1970).

In terms of expenses, almost all farming systems in the area have a low level of variable costs, ranging from 20,000 to 30,000 baht, except for the NRFP3 and NRFP6. This is because these two farming systems are associated with sugarcane, a labour-intensive crop. The expenses of all the farming systems included fertilizer and wages during the planting and harvesting stages (see Table E.3). The cost of feed for cattle in the integrated crop and livestock farming systems were fairly low. This is either because the farmers have only small herds of cattle or the farmers feed their herds by letting the cattle graze on the public land. In addition, the results show that all the alternative farming systems in the area have a low proportion of fixed costs in the total production costs (approximately 15 per cent).

The results from the north-east irrigated area showed that NIFP1 had an average gross farm income of 118,073 baht, followed by 111,200 and 82,843 baht for NIFP2 and NIFP3 system, respectively. Rice-intensive production was the main farm activity and provided quite similar gross farm income across all farms. NIFP2 represented the highest average total variable costs among the farming systems in this area. Most of the expenses were for the planting and harvesting stages; to buy chemical fertilizers, pay for hired labour and renting farm machinery (see Table E.4).

Based on the survey results, it is likely that the farming systems in the north-east are classified as traditional agricultural production. This is because of the low usage of large farm machinery among the north-east farmers compared with the central region farmers. North-east farmers generally owned hand tractors and use them efficiently for multi purposes on their farms. In addition, the costs to operate large farm machinery, such as four-wheel tractors, are very high, whereas the income of the north-east farmers were quite low.

Table 6.9 Average net farm income of each farming system in north-east Thailand, 2008 year price levels (n=400)

Farming system	*Average (baht)*				
	Total farm income [a]	*Total variable cost* [a]	*Gross margin*	*Total fixed cost* [a]	*Net farm income*
		Rain-fed area			
NRFP1: *WSR*	27,496.26	11,955.21	15,541.04	2,388.77	13,152.27
NRFP2: *WSR + cassava*	62,147.84	28,583.11	33,564.73	5,332.71	28,232.02
NRFP3: *WSR + sugarcane*	110,038.45	58,990.34	51,048.10	6,069.19	44,978.91
NRFP4 [b]: *WSR with cattle*	71,948.80	22,695.80	49,253.00	4,587.49	44,665.51
NRFP5 [b]: *WSR + cassava with cattle*	67,561.00	28,813.00	38,748.00	5,068.08	33,679.92
NRFP6 [b]: *WSR + sugarcane with cattle*	97,238.57	43,030.00	54,208.57	4,119.47	50,089.09
All rain-fed area farms	62,356.69	27,102.31	35,254.38	4,351.17	30,903.20
		Irrigated area			
NIFP1: *WSR → DSR I*	118,073.18	48,085.22	69,987.96	6,530.75	63,457.20
NIFP2: *WSR → DSR I + tomato*	111,220.00	49,533.33	61,686.67	4,178.37	57,508.29
NIFP3 [b]: *WSR → DSR I with cattle*	82,843.73	38,010.43	44,833.30	4,554.84	40,278.46
All irrigated area farms	108,698.25	44,097.00	64,601.25	5,770.43	58,830.81
All north-east farms	81,820.14	34,240.08	47,580.06	4,947.26	42,632.80

Note: WSR=wet rice; and DSR I=first crop of dry rice
[a] See more details in Tables E.3 and E.4 in Appendix E
[b] Crop-livestock farming system

Source: Field survey, 2009

6.3 Results of the stochastic efficiency analysis

In this section, the risk efficiency of the different farming systems in the central and north-east regions are assessed and compared. Using stochastic efficiency with respect to a function (SERF), risk efficiency for alternative farming systems was ranked using certainty equivalents (CEs) over a range of $r_a(w)$ values (see Section 4.5.6).

As discussed in Section 6.1.1, a negative exponential utility function performed best to describe the $r_a(w)$ of smallholder farmers in central and north-east Thailand. Therefore, the relevant range of the lower and upper bounds of $r_a(w)$ were employed for the SERF analysis. The $r_a(w)$ ranged from 0.0000144 (slightly risk averse) to 0.0001330 (extremely risk averse) for the central region farmers, and $r_a(w)$ ranged from 0.0000109 (slightly risk averse) to 0.0012450 (extremely risk averse) for the north-east farmers.

In order to calculate the CE with respect to a negative exponential utility function following equation 4.14, the stochastic simulation model was estimated to generate the probability distribution of net farm income for each farming system (see equation 4.15).The deterministic variables including the effective areas used to grow individual crops, heads of livestock sold, total variable costs and total fixed costs for each farming system were based on the results from the observed farms for the 2008 crop year price levels. In addition, the historical data on prices and yields of each individual crop and prices for livestock were collected from the statistical datasets of the Office of Agricultural Economics. The stochastic simulation was generated using 1998 to 2008 historical data (see Appendix F for details).

The SERF analysis for the risky different farming systems in the central and north-east regions were simulated using the SIMETAR program; the results are discussed below.

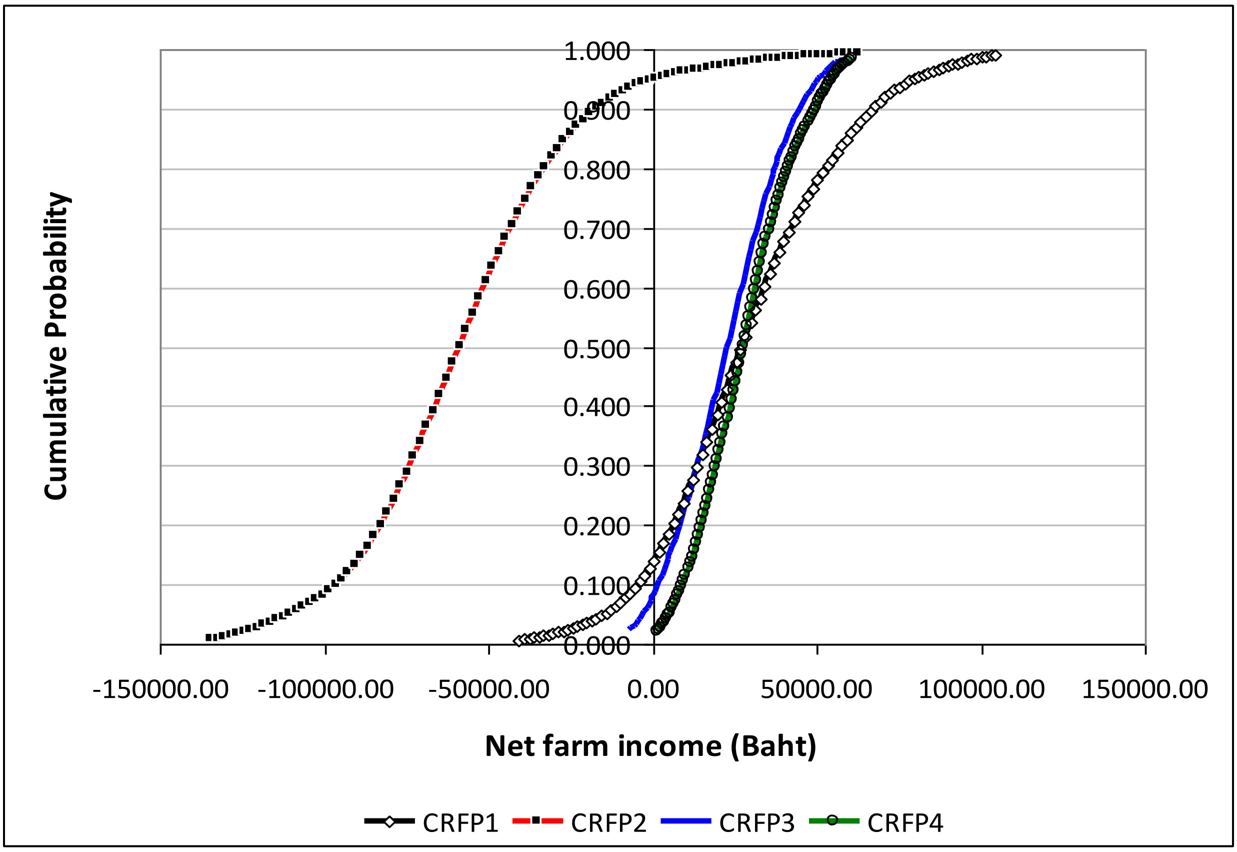
6.3.1 Central region rain-fed area

Figure 6.1 shows the cumulative distribution functions (CDFs) for the net farm income of each farming system in the central region rain-fed area. The results indicated that CRFP1 can exhibit higher net farm income than the other farming systems. However, the CDF for CRFP1 is less steep compared with the CDFs for CRFP3 and CRFP4. This implies that CRFP1 has a more uncertain net farm income than CRFP3 and CRFP4 (Lien et al., 2006). The result shows CRFP1 has about a 12.8 per cent chance of creating negative net farm income. The highest uncertainty in the price of cassava in the central region (coefficient of variation (CV) = 33.48 per cent) may affect net farm income volatility for this farming system (see Table F.1 in Appendix F).

A comparison of the CDFs for CRFP3 and CRFP4 demonstrates that both farming systems have a low possibility of generating a negative net farm income. The result clearly shows CRF3 has almost 92.6 per cent chance of achieving a positive net farm income, whereas CRFP4 has no chance of experiencing returns lower than the total production expenses. Although there are relatively high uncertainties in prices of maize and sorghum in the central region, both commodities have experienced low variation in yields. This may have resulted in CRFP3 and CRFP4 being less risky farming systems compared with CRFP1. In contrast, CRFP2 is associated with a 95 per cent chance of generating a negative net farm income. The high variation in the price of sugarcane in the central region and high production expenses of this farming system are the main causes driving CRFP2 to exhibit high net farm income volatility.

The expected value of net farm income for the simulated CRFP1 is 29,095 baht, for CRFP4 28,268 baht, for CRFP3 23,086 baht and for CRFP2 -57,177 baht.

Figure 6.1 Simulated cumulative distribution functions (CDFs) of annual net farm income ($\tilde{A}$) for the different farming systems (CRFP1-4) in Thailand's central region rain-fed area

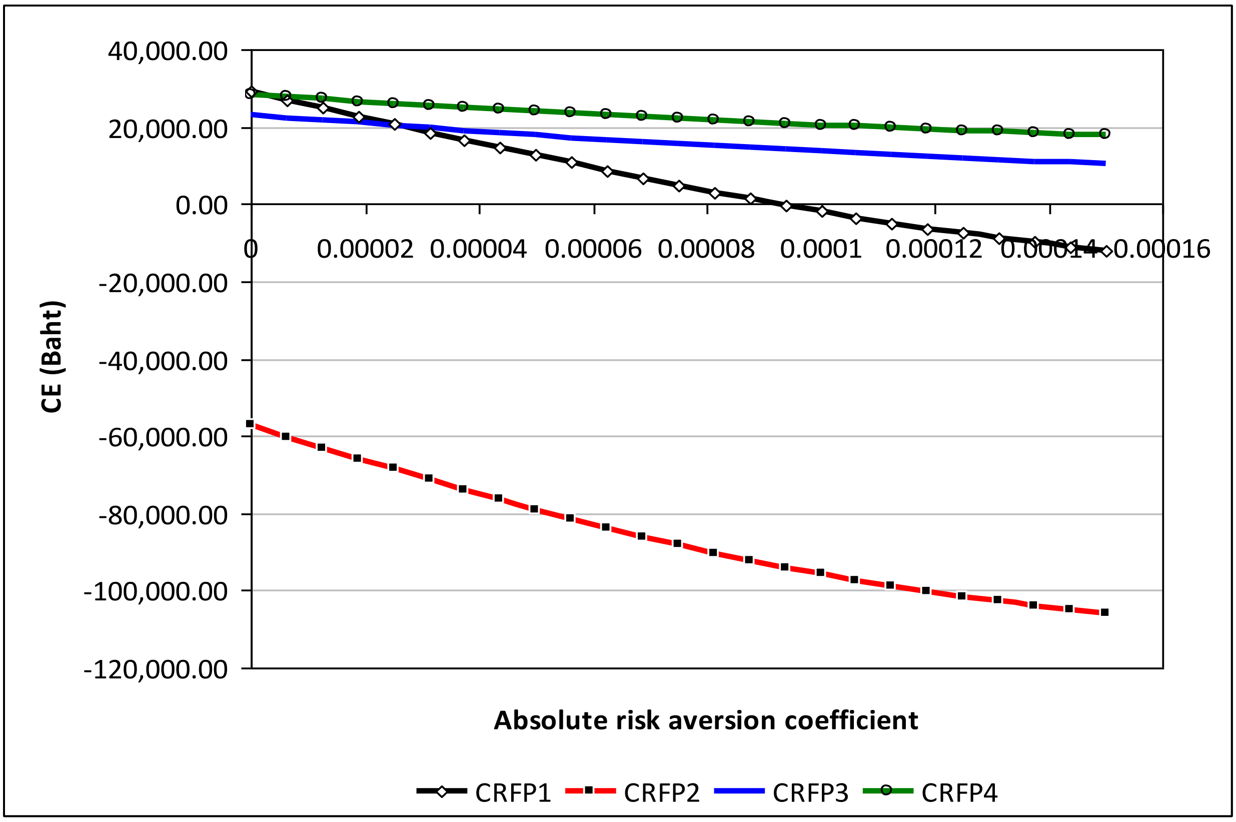


The SERF analysis results for the different farming systems in the central region rain-fed area over the $r_a(w)$ range of zero (risk-neutral) to 0.0001330 with respect to the negative exponential utility function are given in Figure 6.2. Figure 6.2 shows CRFP4 would be preferred by the slightly risk averse to the extremely risk averse central region rain-fed farmers over the CRFP3, CRFP1 and CRFP2. This is because CRFP4 has a higher CE than the other farming systems. However, CRFP1 would be slightly more preferred than the other farming systems by risk-neutral central region rain-fed farmers.

In other words, in the central region rain-fed area, CRFP4 is the most risk efficient farming system for all levels of risk averse farmers, whereas CRFP1 was preferred by the risk neutral farmers.

It can be seen that, although CRFP2 generated the highest average net farm income for the central region rain-fed farmers using the 2008 year price levels (see Table 6.8), the CRFP2 system had the lowest expected value of net farm income and had the highest chance of generating negative net farm income when using stochastic simulation. This may have resulted from growing sugar cane, which is associated with a high cost of production and would not be appropriate for small scale central region rain-fed farmers. Therefore, CRFP4 and CRFP1 are considered suitable in terms of risk efficient farming system options for risk averse and risk neutral central region rain-fed farmers, respectively. The results imply that the extremely risk averse central region rain-fed farmers may significantly increase their net farm income sustainability by growing CRFP4.

Figure 6.2 Certainty equivalents (CEs) of the different farming systems (CRFP1-4) in Thailand's central region rain-fed area with the different magnitudes of absolute risk aversion coefficient with respect to a negative exponential utility function



6.3.2 Central region irrigated area

The CDFs for net farm income of the alternative farming systems in the central region irrigated area are summarized in Figure 6.3. The results show that CIFP2 can generate a higher net farm income than CIFP1. However, the less steep slope of the CDF for CIFP2 compared with CIFP1 implies that CIFP2 was a more risky farming system than CIFP1.

The simulated CIFP2 has a 24.6 per cent chance of a negative net farm income, whereas CIFP1 has a 23.8 per cent chance to generate a negative net farm income. There are two reasons driving either CIFP1 or CIFP2 to produce a high uncertain net farm income. First, although rice is an important crop for central region irrigated farmers, the price of rice in this region fluctuates widely from year to year, especially for dry rice (CV = 37.36 per cent) (see Table F.1). Second, the aggressive use of chemical fertilizers, high wage costs and the high cost of land rent in the central region irrigated area increased production costs in both farming systems.

The expected net farm income for the simulated CIFP2 and CIFP1 are 50,312 and 26,651 baht, respectively.

Figure 6.3 Simulated cumulative distribution functions (CDFs) of annual net farm income ($\tilde{A}$) for the alternative farming systems (CIFP1 and CIFP2) in Thailand's central region irrigated area

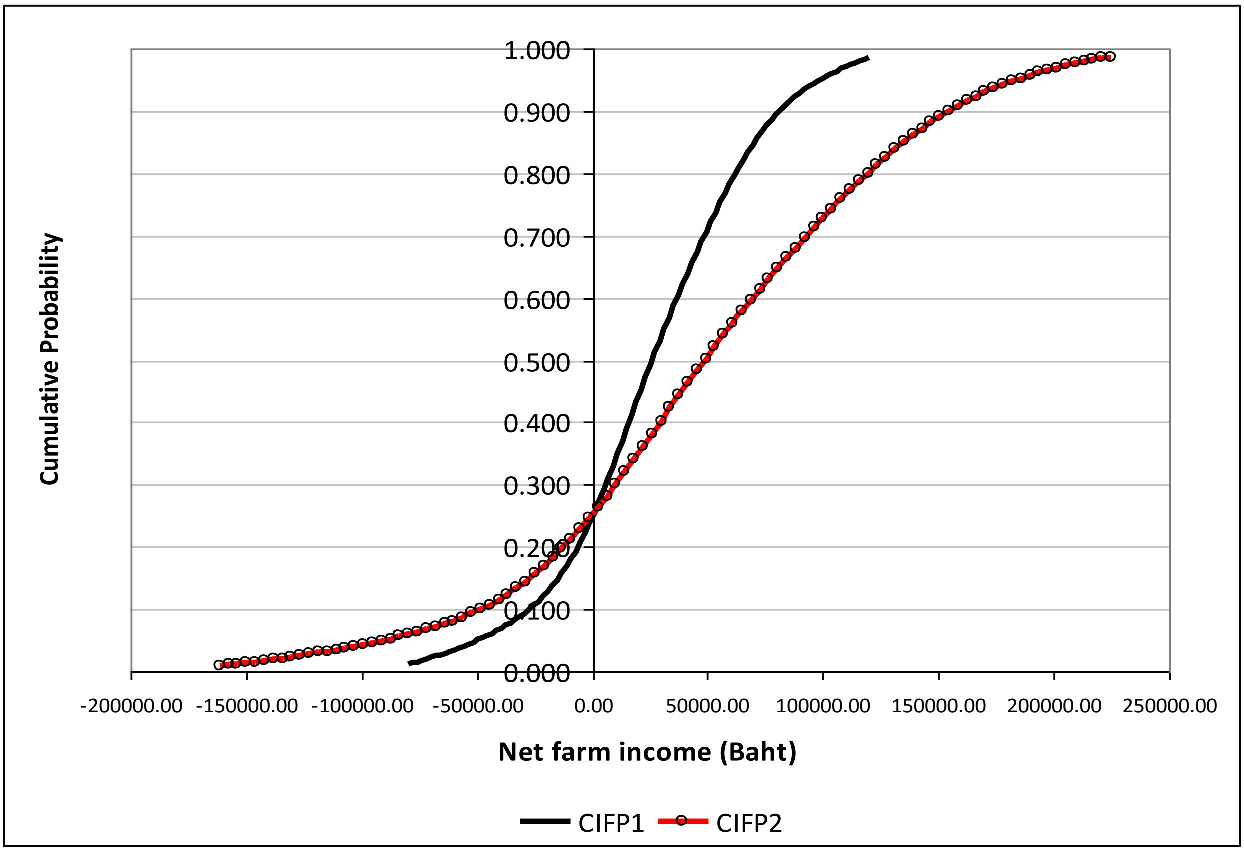
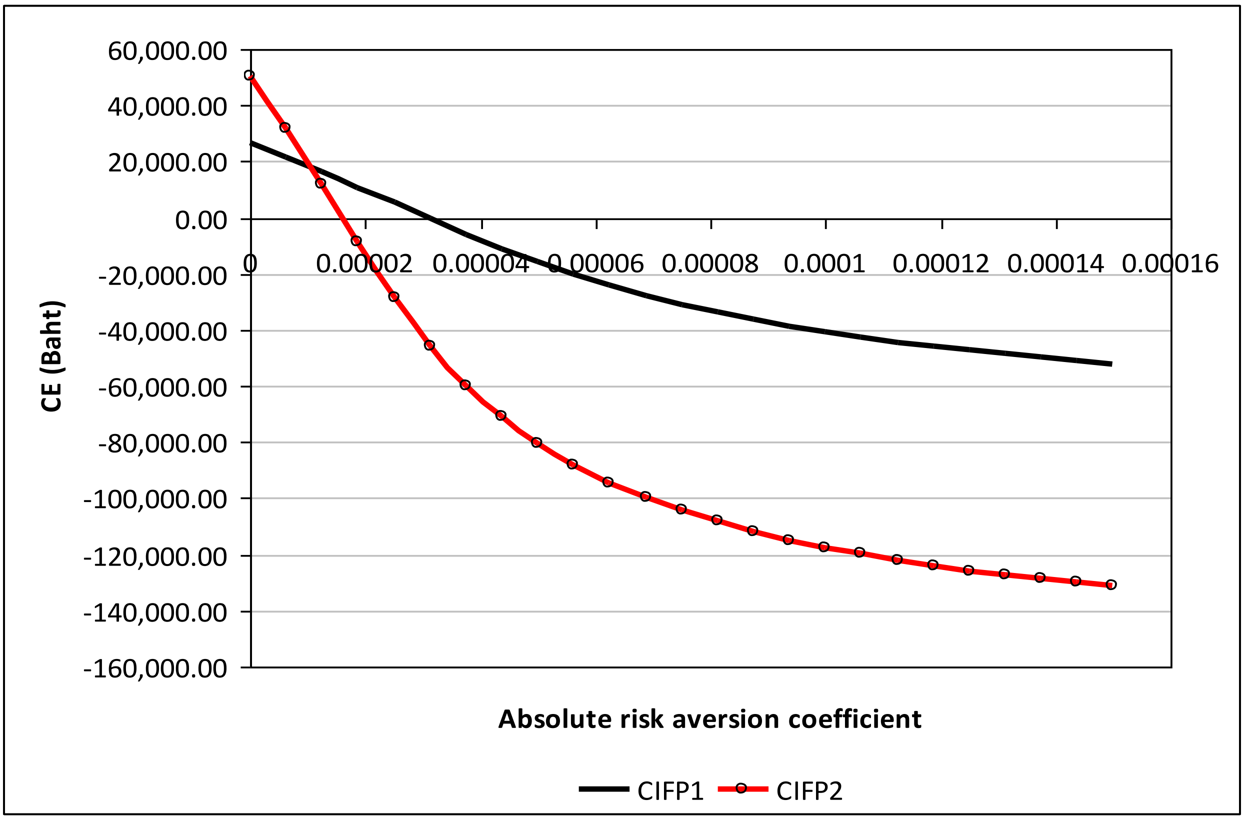


Figure 6.4 illustrates the SERF analysis results for CIFP1 and CIFP2 over the $r_a(w)$ ranges from zero to 0.0001330 with respect to the negative exponential utility function. The results show CIFP2 is more efficient than the CIFP1 when the $r_a(w)$ ranges from zero to 0.0000125. This implies that CIFP2 is the preferred farming system for risk neutral and some of the slightly risk averse central region irrigated farmers.

Above the $r_a(w)$ of 0.0000125, central region irrigated farmers preferred CIFP1 over CIFP2. We can conclude that CIFP1 is the most risk efficient farming system for the extremely risk averse central region irrigated farmers. In addition, at the point where CIFP1 and CIFP2 cross, the farmer is indifferent between the two alternative farming systems.

Overall, using the 2008 price levels (see Table 6.8), CIFP2 appeared to generate higher average net farm income for central region irrigated farmers and has higher expected net farm income than CIFP1 when using stochastic simulation. However, due to the unstable price of rice in the area combined with high production costs, both farming systems have somewhat high probabilities of giving a negative net farm income. Therefore, CIFP1 would be suggested as the risk efficient farming system appropriate for the extremely risk averse central irrigated farmers, whereas the risk neutral and some of the slightly risk averse farmers (those who have $r_a(w)$ less than 0.0000125) would preferred CIFP2. The results imply that the extremely risk averse central region irrigated farmers may significantly increase their net farm income sustainability by growing CIFP1.

Figure 6.4 Certainty equivalents (CEs) of the alternative farming systems(CIFP1 and CIFP2) in Thailand's central region irrigated area with the different magnitudes of absolute risk aversion coefficient with respect to a negative exponential utility function

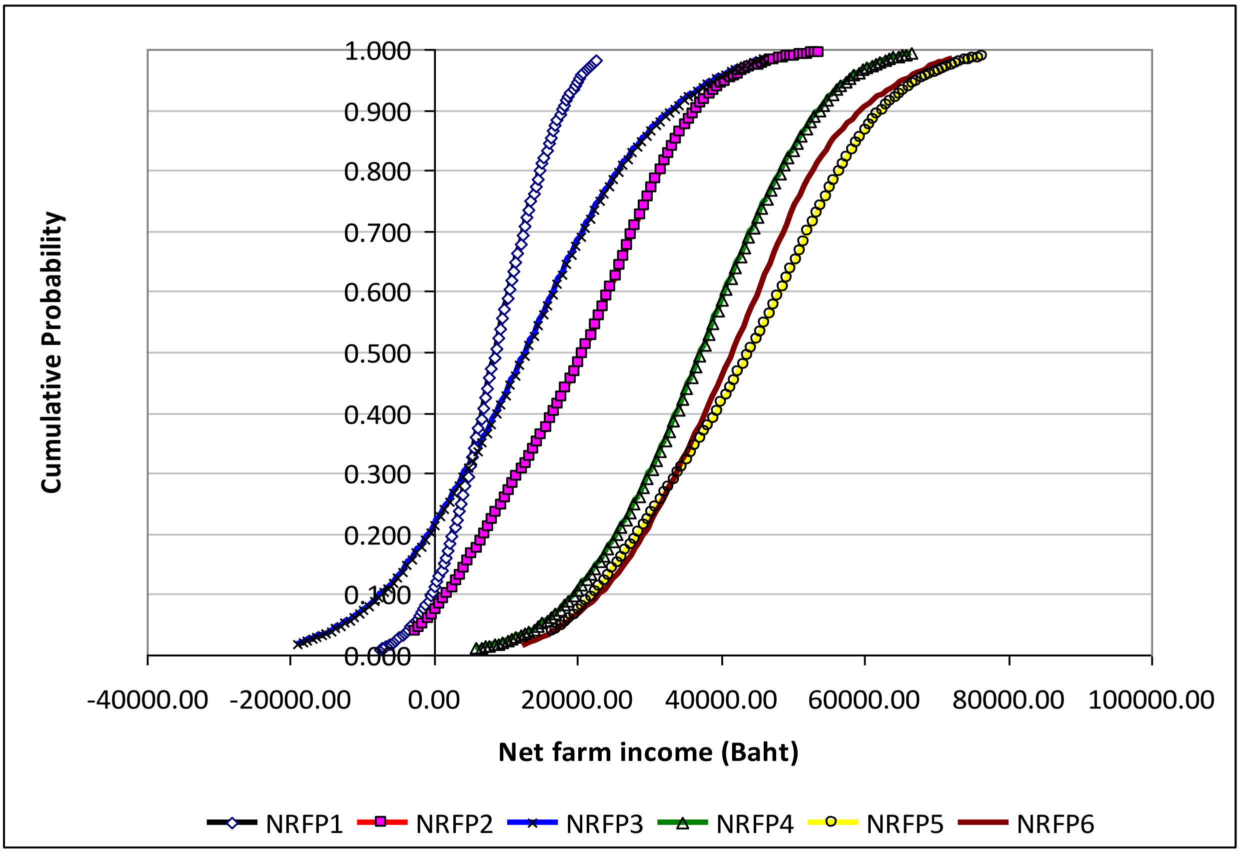


6.3.3 North-east region rain-fed area

Figure 6.5 presents the CDFs of net farm income for the farming systems in the north-east rain-fed area. It appears that NRFP5 can generate a higher net farm income than the other farming systems in the area.

NRFP3 has a 20.3 per cent probability of obtaining a negative net farm income, whereas NRFP1 and NRFP2 have probabilities of 10.6 and 6.6 per cent, respectively. There are two factors that affected the net farm income volatility among these single-crop and multiple-crop farming systems. First, the low productivity and high uncertainty of price of wet rice (CV = 26.22 per cent), which is the main cash crop for rice-based farmers in the rain-fed area of north-east Thailand (see Tables F.2 and F.4). Second, there is the high uncertainty of price of cassava (CV = 31.84 per cent) combined with the high production costs of sugarcane.

Figure 6.5 Simulated cumulative distribution functions (CDFs) of annual net farm income ($\tilde{A}$) for the different farming systems (NRFP1-6) in Thailand's north-east region rain-fed area



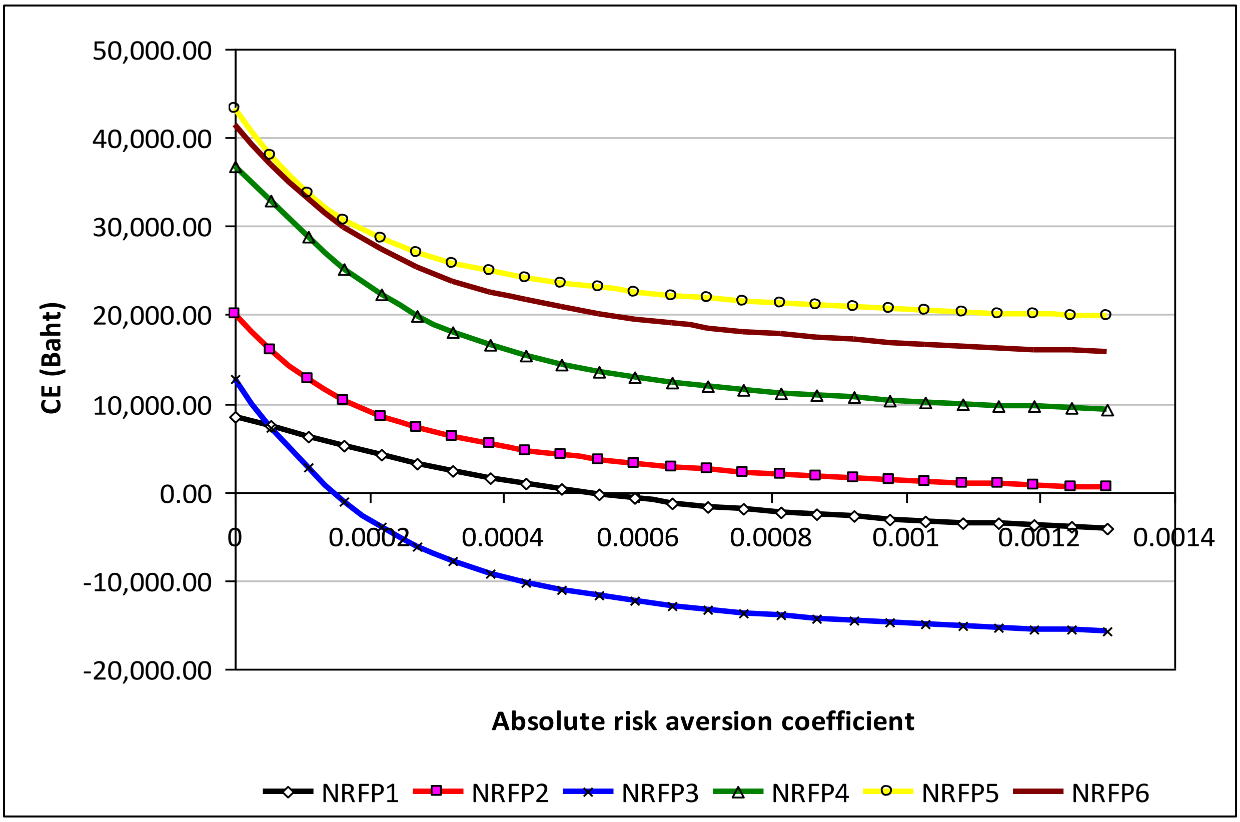
The results also show that the volatility in net farm income is reduced within the crop-livestock alternative farming systems. The simulated NRFP4-6 shows no probability of generating a negative net farm income. We can conclude that raising cattle could help increase farm income diversification and serve as a buffer to protect farm income volatility for north-east rain-fed farmers.

The expected net farm income for the simulated NRFP5 is 43,189 baht, followed by 41,428 baht for NRFP6 and 36,860 baht for NRFP4. NRFP1 had the lowest expected net farm income of 8,542 baht. The expected net farm income for NRFP3 was 12,697 baht and 20,004 baht for the NRFP2.

The ranked CEs of the farming systems in the north-east region rain-fed area over the $r_a(w)$ ranges from zero to 0.0012450 with respect to the negative exponential utility function are shown in Figure 6.6. The results show that NRFP5 is the most risk efficient farming system for all risk averse north-east rain-fed farmers because NRFP5 lies highest on the graph within this range of $r_a(w)$. NRFP6 and NRFP4 are the second and third most preferred farming systems at all risk aversion levels.

It can be seen that the crop-livestock farming system options (NRFP4-6) generated higher average net farm income using the 2008 price levels compared with other farming systems (see Table 6.9). Similarly, when using stochastic simulation, NRFP4-6 appeared to generate high expected values of net farm income and had no probability of a negative net farm income. This finding implies that crop-livestock farming systems are more risk efficient than single-crop and multiple-crop farming systems and appropriate to reduce net farm income volatility for north-east rain-fed farmers. NRFP5 is considered as the most risk efficient farming system and is appropriate for all levels of risk averse farmers. The results imply that the extremely risk averse north-east rain-fed farmers may significantly increase their net farm income sustainability by growing NRFP5.

Figure 6.6 Certainty equivalents (CEs) of the different farming systems (NRFP1-6) in Thailand's north-east region rain-fed area with the different magnitudes of absolute risk aversion coefficient with respect to a negative exponential utility function



6.3.4 North-east region irrigated area

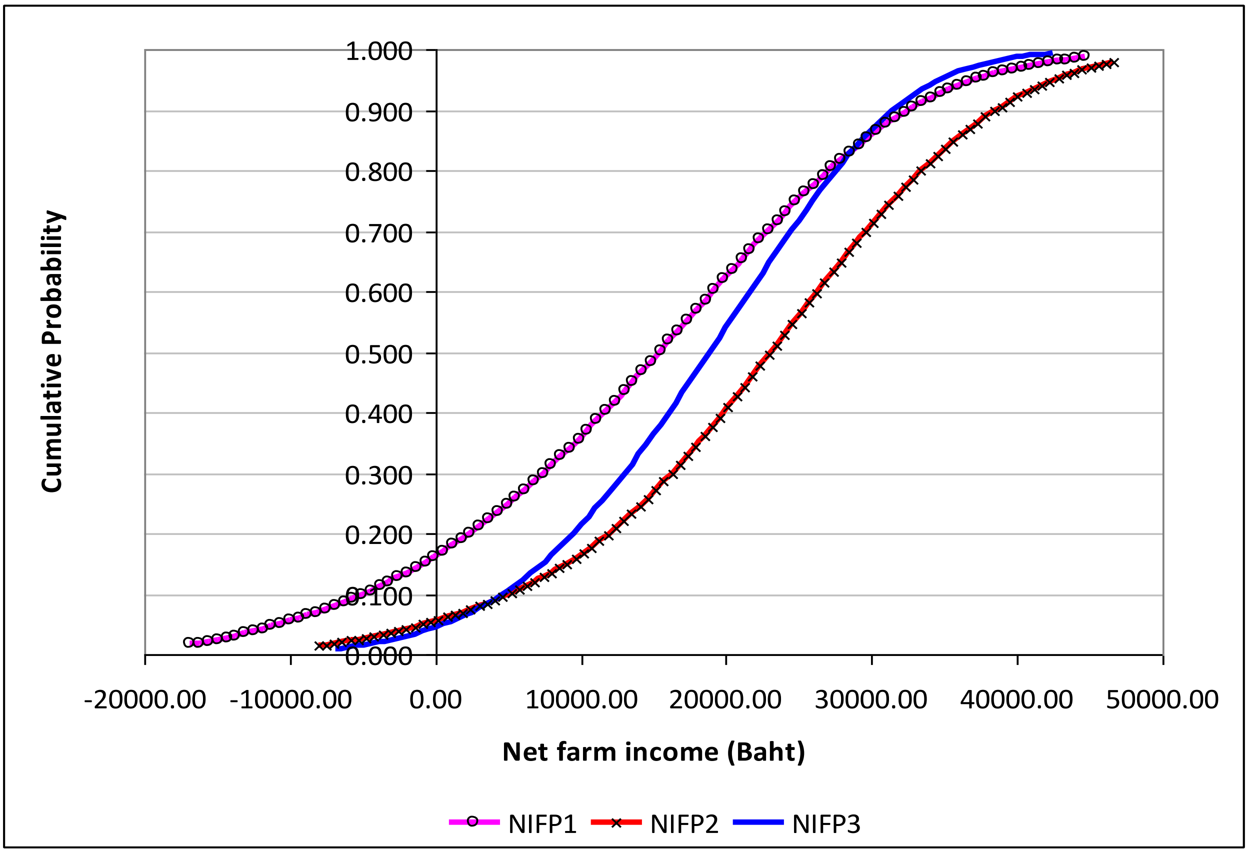
Figure 6.7 presents the CDFs for the net farm income of the farming systems in the north-east irrigated area. The results show that simulated NIFP2 can generate a higher net farm income than NIFP3 and NIFP1. However, NIFP2 has a probability of 5.3 per cent of a negative net farm income. NIFP3 has the lowest probability, less than five per cent, of generating a negative net farm income. NIFP1 has a probability of 16.1 per cent of generating a negative net farm income.

It is likely that relatively low yields, combined with the high uncertainty of the price of either wet rice or dry rice (CV = 25.10 and 29.22 per cent, respectively), may have influenced the volatility of net farm income for the high-intensity rice alternative farming systems in the north-east irrigated area (see Tables F.2 and F.4).

The expected values of net farm income for these three farming systems are quite similar. The simulated NIFP2 generated the highest expected net farm income of 22,405 baht, followed by

NIFP3 with an expected net farm income of 18,477 baht and NIFP1 with an expected net farm income of 14,661 baht.

Figure 6.7 Simulated cumulative distribution function (CDFs) of annual net farm income ($\tilde{A}$) for the different farming systems (NIFP1-3) in Thailand's north-east region irrigated area

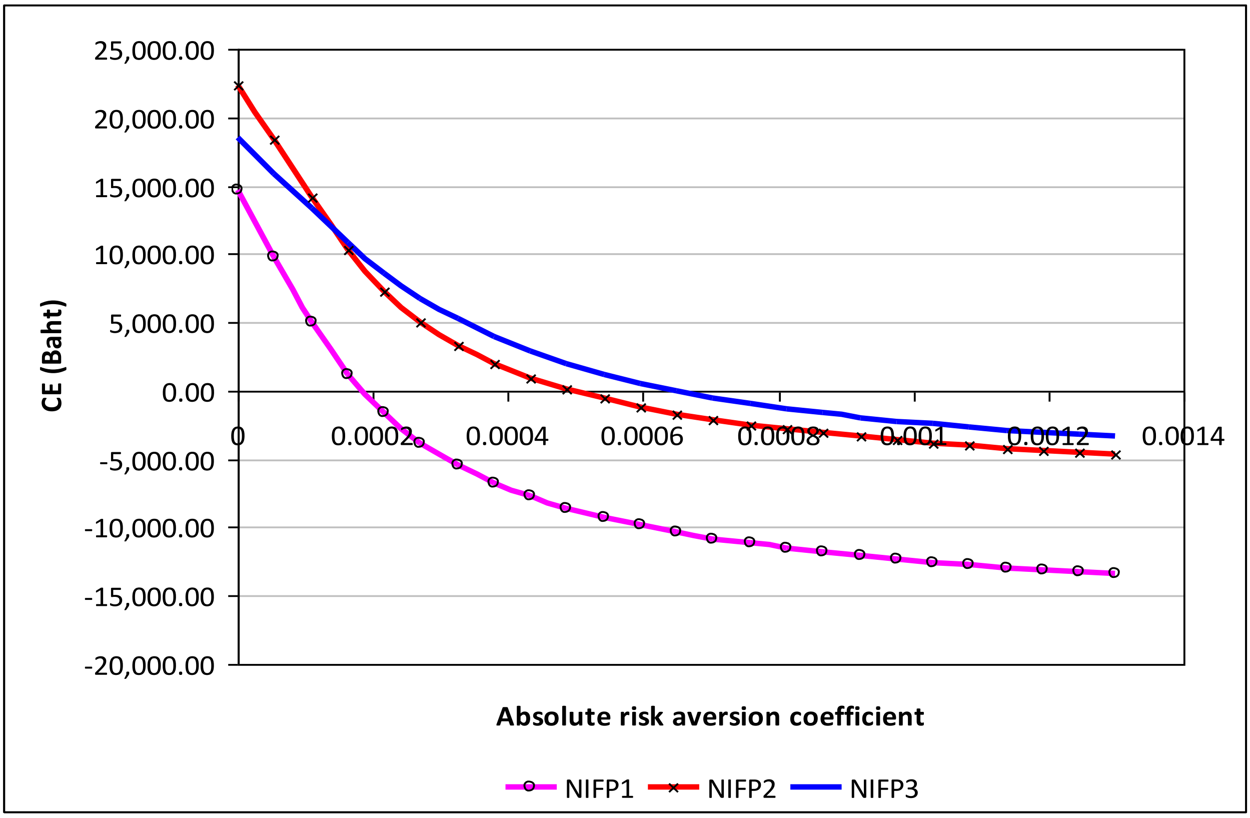


The SERF analysis results for the different farming systems in the north-east irrigated area are summarized in Figure 6.8. The CE of each farming system is ranked over the $r_a(w)$ ranges from zero to 0.0012450 under the negative exponential utility function. The results show that NIFP2 is the preferred farming system when the $r_a(w)$ ranges between zero and 0.0001625. This means that NIFP2 is risk efficient over the other farming systems and appropriate for risk neutral north-east irrigated farmers and some of the slightly risk averse farmers (those who have $r_a(w)$ less than 0.0001625).

In addition, above the $r_a(w)$ of 0.0001625, NIFP3 is higher on the graph than NIFP2. This illustrates that NIFP3 is the most risk efficient farming system and suitable for the extremely risk averse north-east irrigated farmers.

In summary, using the 2008 price levels (see Table 6.9), NIFP1 appeared to generate the highest average net farm income for the north-east irrigated farmers. However, due to the low productivity and unstable prices of rice in the area, NIFP1 generated the lowest expected value of net farm income and had the highest probability to generate negative net farm income when using stochastic simulation. Therefore, NIFP3 would be considered as a risk efficient farming system appropriate for extremely risk averse north-east irrigated farmers, whereas the risk neutral and some of the slightly risk averse farmers (those who have $r_a(w)$ less than 0.0001625) would prefer NIFP2. The results imply that the extremely risk averse north-east irrigated farmers may significantly increase their net farm income sustainability by growing NIFP3.

Figure 6.8 Certainty equivalents (CEs) of the different farming systems (NIFP1-3) in Thailand's north-east region irrigated area with the different magnitudes of absolute risk aversion coefficient with respect to a negative exponential utility function



6.4 Sensitivity analysis

As discussed in Section 6.3, high uncertainty in commodity prices is one of the most important factors that impacted net farm income volatility for the farming systems in the central and north-east regions. Therefore, a sensitivity analysis was conducted in order to investigate the effects of commodity price inflation on net farm income volatility for the farming systems in this study.

The consumer price index (CPI) of Thailand 1998-2008 (see Table G.1 in Appendix G) was used to estimate the inflation-adjusted (real) prices for each individual crop in 2008 Thai baht. This procedure aimed to eliminate misleading interpretations regarding the effects of inflation from the commodity prices. The details of inflation adjusted prices for each individual crop in the central and north-east regions are documented in Tables G.2 and G.3.

The result showed that all CVs of the inflation adjusted prices for each individual crop in 2008 baht values were somewhat smaller than the CVs of non-inflation adjusted (nominal) prices. This implies that there is less variability in the inflation adjusted commodity prices. Specifically, the SERF analysis was performed using the inflation adjusted crop prices to examine the changes in net farm income volatility for each farming system. The sensitivity analysis simulation results are presented in Appendix H. The differences between the simulated results using real and nominal commodity prices are discussed below.

The CDFs of net farm income for the different farming systems in the central region rain-fed area, using inflation-adjusted crop prices, are illustrated in Figure H.1 in Appendix H. Comparing Figure H.1 with Figure 6.1, there are slight increase in the expected net farm incomes for CRFP1, CRFP3 and CRFP4. The possibility of generating a negative net farm income for CRFP1 decreases to 5.5 per cent, but CRFP3 has no chance of obtaining a negative net farm income. Despite this, CRFP2 still has a negative expected net farm income; the probability of receiving a negative net farm income dropped from 92.6 to 85 per cent when simulated with the real price of sugarcane. Moreover, the SERF sensitivity analysis results illustrated in Figure H.2 indicate that CIFP4 is the most risk efficient farming system for all levels of risk aversion considered, when inflation is not accounted for in the commodity prices.

For the central region irrigated area, CIFP1 and CIFP2 have a 10 per cent probability of generating a negative net farm income (see Figure H.3). The expected net farm incomes increased to 92,647 baht for CIFP2 and 52,864 baht for CIFP1, when simulated using the real commodity prices. On the one hand, the SERF sensitivity analysis results show that CIFP2 is the preferred faming system by the risk neutral and some of the slightly risk averse central region irrigated farmers (those who have $r_a(w)$ of zero to 0.0000221). On the other hand, the central region irrigated farmers who have $r_a(w)$ greater than 0.0000221 would prefer CIFP1 over CIFP2 (see Figure H.4).

Figure H.5 shows the simulated CDFs of the alternative farming systems in the north-east rain-fed area using real commodity prices in 2008 baht values. The results indicate that

NRFP1, NRFP2 and NRFP3 have less than a five per cent probability of experiencing a negative net farm income. Moreover, the expected net farm incomes for all farming systems in the north-east rain-fed area have increased. NRFP6, NRFP5 and NRFP4 generated the highest expected net farm incomes of 55,779, 55,578 and 47,218 baht, respectively. The simulated NRFP2 had an expected net farm income of 28,605 baht, followed by NRFP3 with an expected net farm income of 25,232 baht and NRFP1 with an expected net farm income of 12,179 baht. The SERF sensitivity analysis results shown in Figure H.6 indicate that NRFP6 is the most risk efficient farming system across various risk aversion levels of the north-east rain-fed farmers. This result is completely different from the previous simulation using nominal commodity prices.

The CDFs of net farm income for the alternative farming systems in the north-east irrigated area shows that the probability of generating a negative net farm income for NIFP1 dropped from 16.1 to 2.7 per cent when using inflation adjusted commodity prices. NIFP2 and NIFP3 exhibited no chance of obtaining a negative net farm income (see Figure H.7). The expected net farm incomes for all farming systems in the north-east irrigated area increased slightly. NIFP2 had the highest expected net farm income of 34,425 baht. As documented in Figure H.8, NIFP2 was preferred by the risk neutral and slightly risk averse north-east irrigated farmers when inflation is not accounted for in the commodity prices. However, the extremely risk averse north-east irrigated farmers (those who have $r_a(w)$ greater than 0.0007781) preferred NIFP3, since the CE is slightly higher than for the NIFP2.

Overall the SERF-sensitivity analysis results show, the net farm income volatility for all alternative farming systems in central and north-east Thailand are reduced when inflation adjusted commodity prices were used instead of the non-inflation adjusted prices. SERF assessed the most risk efficient farming system in each of the study area, which were quite similar to the previous simulations, except for the north-east rain-fed area.

6.5 Summary of findings

In conclusion, the results showed that the negative exponential utility function performed best among the other selected functional forms in explaining the risk behaviour of the farmers in central and north-east regions. The $r_a(w)$ given by the negative exponential function described risk behaviour of the observed farmers in both regions as risk averse. The $r_a(w)$ ranged from 0.0000144 to 0.0001330 for the farmers in the central region, and $r_a(w)$ ranged from 0.0000109 to 0.0012450 for the north-east farmers. In addition, the independent sample t-test results showed that the $r_a(w)$ between the central and north-east region farmers were not significantly different.

The results of the multivariate regression of risk aversion against the socio-economic characteristics of the farmers indicated that Highest Education and Household Size were significant and negatively impacted the risk aversion of the farmers in the central region, but Age was negative and significantly influenced the risk aversion of the north-east region farmers. However, the effects of the wealth variable (Net Farm Income) on risk aversion of the farmers are ambiguous in both regions.

In terms of stochastic efficiency analysis, the results revealed that maize followed by sorghum (CRFP4) was the most risk efficient farming system for slightly to extremely risk averse farmers' in the central region rain-fed area. The extremely risk averse central region irrigated farmers preferred growing low land wet rice followed by one crop of dry rice (CIFP1), but three low land rice crops (CIFP2) system was suitable for slightly risk averse central region irrigated farmers.

Multiple crops of rice and cassava, combined with raising small herds of cattle (NRFP5) was a stochastically risk efficient farming system for all risk averse north-east rain-fed farmers. For the north-east irrigated area, two rice crops and raising cattle (NIFP3) was the most risk efficient for the extremely risk averse farmers, but two rice crops and tomatoes (NIFP2) was preferred by the slightly risk averse north-east irrigated farmers

Chapter 7
Summary and Conclusions

This chapter presents a summary of the research. Section 7.1 provides the conclusions and the findings of the research. The policy implications derived from the findings are discussed in Section 7.2. In the following section, the limitations of the research are presented. The recommendations for future research are discussed in Section 7.4.

7.1 Summary and empirical findings

Agricultural production faces a number of unpredictable risks. The variability of yields and unstable input and output prices are important sources of risk that produce farm income volatility. The severity of the risk can vary considerably depending on the farming system, geographic location, weather conditions, government support policies, farm prices and farm types. For several decades, Thai farmers have experienced pervasive and complicating risks that caused their farm incomes to fluctuate every year, especially for small scale farmers. Therefore, the findings from this research will enhance our understanding of the important sources of risk confronting Thailand's farmers, and the impacts of those risks at the farm level, so that positive ways to minimize the effects of risk on farms can be developed that will help farmers survive and deal with the risks.

The objective of this research was to identify the important sources of risk and risk management strategies of smallholder farmers in the central and north-east Thailand. This research also assessed the farmers' utility functions and the risk attitudes in both regions. In addition, this research estimated the risk efficient farming system options for smallholder farmers in each study region. The different farming resources and the economic development in the two regions provided the basis for a comparison of the results using risk efficiency criteria.

This research used both primary and secondary data sources. The primary data were gathered from a field survey of smallholder farmers in central and north-east Thailand. The sample selection process involved two stages. First, the provinces in each region were grouped into those provinces with large and medium irrigation systems and those in the rain-fed areas. Secondly, a purposive random sampling technique was employed to draw out samples from each group. Eight hundred respondents from eight provinces in the central and north-east regions were interviewed. Face-to-face interviews were performed to elicit relevant information. The data collection process was carried out from January to April 2009. In addition, time series data of prices and yields at the provincial level from the 1998 to 2008 crop years were obtained from the OAE database for each individual crop and livestock species in the study area. Both primary and secondary data were employed in a stochastic simulation model to determine the risk efficiency of each farming system.

The approaches employed to analyse the data include several steps. First, the sources of risk the smallholder farmers in both regions perceived as most important, and the risk management strategies they used to cope with the risks, were measured using a five-point Likert scale. Exploratory factor analysis (EFA) was applied to reduce the large number of sources of risk and risk strategy variables. In addition, the associations between smallholder farmers' characteristics and the perceptions of sources of risk and risk strategy components were assessed using multiple regression. Second, the smallholder farmers' attitudes towards risk were elicited using the equal likely certainty equivalent (ELCE) technique. Four alternative utility function forms were selected to calculate the absolute risk aversion coefficients and compare their performances in terms of the risk preference classification. Multiple regressions were used to investigate wealth and non-wealth factors influencing the smallholder farmers' risk aversion. Lastly, the different risky farming systems of smallholder farmers in both regions were evaluated using the stochastic efficiency with respect to a function (SERF) approach. Each alternative farm plan was simulated and ranked based on its certainty equivalent (CE) over a defined range of risk aversion values using SIMETAR software.

The findings of the perceptions of sources of risk and risk management strategies indicated some notable differences between farmers in the central and north-east regions and also between the farmers in the irrigated and rain-fed areas of both regions. Tables 7.1 and 7.2 summarize the five most important sources of risk and risk management strategies perceived by farmers in each group.

The results showed that marketing risks associated with 'unexpected variability of input prices' and 'unexpected variability of product prices' were major concerns of the farmers in both regions. Production risks related to 'diseases and pests affecting plants and animals' and 'excess rainfall' were considered as important by the central region farmers, but the north-east farmers ranked these risks lower. Additionally, concern among the north-east farmers regarding institutional risks associated with 'changes in Thailand's economic and political situation' and 'changes in national government laws and policies' were significantly higher than for the central region farmers.

Marketing risks associated with 'unexpected variability of input prices' and 'unexpected variability of product prices' were also major concerns among farmers in the irrigated and rain-fed areas of both regions. However, 'deficiency in rainfall causing drought' was ranked most and second most important by farmers in rain-fed areas of the central and north-east regions, respectively. Farmers in the irrigated area of both regions were more concerned about 'diseases and pests that affect plants and animals', 'excess rainfall' and 'natural disaster', but these risks were only of moderate importance to farmers in rain-fed areas. Moreover, 'changes in Thailand's economic and political situation' and 'changes in national government laws and policies' were considered as important sources of risk for north-east rain-fed farmers who showed a higher degree of concern than the farmers in other groups.

Table 7.1 Five most important sources of risk perceived by Thailand's smallholder farmers in central and north-east regions

Rank	*All farmer group*		*Central region farmer group*		*North-east region farmer group*	
	Central	*North-east*	*Irrigated*	*Rain-fed*	*Irrigated*	*Rain-fed*
1	Unexpected variability of input prices	Unexpected variability of input prices	Unexpected variability of input prices	Deficiency in rainfall causing drought	Unexpected variability of input prices	Unexpected variability of input prices
2	Unexpected variability of product prices	Unexpected variability of product prices	Unexpected variability of product prices	Unexpected variability of input prices	Unexpected variability of product prices	Deficiency in rainfall causing drought
3	Diseases and pests that affect plants and animals	Changes in Thailand's economic and political situation	Diseases and pests that affect plants and animals	Unexpected variability of product prices	Natural disaster such as heat, fire, flood, storm	Unexpected variability of product prices
4	Excess rainfall	Changes in national government law and policies	Excess rainfall	Diseases and pests that affect plants and animals	Diseases and pests that affect plants and animals	Changes in Thailand's economic and political situation
5	Unexpected variability of yields	Unexpected variability of yields	Unexpected variability of yields	Problem with hired labour	Changes in Thailand's economic and political situation	Changes in national government law and policies

The results from the perceptions of risk management strategies suggested that production and financial strategies were considered more important than marketing strategies by the central and north-east region farmers. A production strategy related to 'purchase farm machinery to replace labour' was the most important risk response for the central region farmers, but north-east farmers rated 'storing feed and/or seed reserves' as the most important production strategies. In addition, 'holding cash and easily converted cash assets' and 'working off farm to supplement household income' were considered as important financial strategies by farmers in both regions. The north-east farmers perceived the importance of 'having a farm reservoir for water supplies in dry season' higher than the central region farmers. In contrast, 'apply pests and diseases programme' was considered as important by the central region farmers but was less important for the north-east farmers. The differences between the risk responses of farmers in the central and north-east regions suggested that the farmers in both regions used a mix of risk strategies to cope with the sources of risk they confronted.

The central region irrigated farmers perceived 'purchase farm machinery to replace labour' and 'apply pests and diseases programme' as the important risk strategies, whereas the central region rain-fed farmers preferred 'holding cash' and 'having diversified crop, animal or other enterprises' as risk strategies. 'Storing feed and/or seed reserves' and 'holding cash' were ranked highly among the north-east irrigated and rain-fed farmers. Additionally, the north-east rain-fed farmers rated 'have a farm reservoir' as the most important risk strategy. The results also indicated that the farmers in the rain-fed areas of both regions perceived production strategies related to 'having diversified crop, animal or other enterprises' and 'planting several varieties of crop' significantly greater than the irrigated farmers.

Table 7.2 Five most important risk management strategies perceived by Thailand's smallholder farmers in central and north-east regions

Rank	*All farmer group*		*Central region farmer group*		*North-east region farmer group*	
	Central	*North-east*	*Irrigated*	*Rain-fed*	*Irrigated*	*Rain-fed*
1	Purchase farm machinery to replace labour	Storing feed and/or seed reserves	Purchase farm machinery to replace labour	Holding cash	Storing feed and/or seed reserves	Have a farm reservoir
2	Working off farm	Holding cash	Apply pests and diseases programme	Having diversified crop, animal or other enterprises	Holding cash	Storing feed and/or seed reserves
3	Holding cash	Have a farm reservoir	Working off farm	Obtaining market information	Obtaining market information	Holding cash
4	Apply pests and diseases programme	Obtaining market information	Storing feed and/or seed reserves	Purchase farm machinery to replace labour	Purchase farm machinery to replace labour	Purchase farm machinery to replace labour
5	Reduce debt level	Purchase farm machinery to replace labour	Holding cash	Reduce debt level	Leasing farm machinery rather than owing them	Spreading sale over several time period

EFA was applied to reduce the numbers of sources of risk and risk management strategies of the farmers in each group. Regression analysis was employed to examine the influence of the farm and the farmer's socio-economic characteristics on the farmer's perceptions of sources of risk and risk management strategies as obtained from the factor analysis. The robustness of all models was tested and did not exhibit any problem. However, the coefficients of determination (R^2) of most regression models did not yield satisfactory results. This may imply that the perceptions of sources of risk and risk management strategies were individual and differed from farmer to farmer. However, there were a number of farms and farmers' characteristics that had statistically significant influences on the perceptions of sources of risk and risk management strategies. The findings of the relationships between the farms and the farmers' characteristics with the perceptions of source of risk components for each group of farmer are summarized as follows (see Table 7.3):

For all farmer group

- Female heads of farm households perceived 'personal and farm business environment' and 'natural disaster' as the important sources of risk more than male household heads.
- Young farmers and the farmers who had smaller farms size were more likely to perceive 'natural disaster' as significantly more important source of risk on farm.
- More educated farmers were very concerned with 'personal and farm business environment' risk than did less educated farmers.
- Less experienced farmers, farmers who had higher annual household incomes and farmers with larger sized household rated 'economic and political' as the important sources of risk.
- Farmers who had loans rated 'financial situation' and 'natural disaster' as more important sources of risk than did farmers without loans.
- Farmers who had off-farm work were more likely to rate paying attention to 'economic and political' and 'personal and farm business environment' risks higher than farmers with no off-farm work.
- Central region farmers perceived 'personal and farm business environment', 'natural disaster' and 'financial situation' as more important sources of risk on farm higher than did the north-east farmers. However, the north-east farmers were more concerned about 'economic and political' risks.

Table 7.3 Variables affecting perceptions of source of risk components

Variables	*All farmer group*	*Central region farmer group*	*North-east region farmer group*
Age	(-) Natural disaster		(-) Natural disaster
Gender	(-) Personal and farm business environment (-) Natural disaster	(-) Personal and farm business environment (-) Natural disaster	
Education	(+) Personal and farm business environment	(+) Personal and farm business environment	
Farming experiences	(-) Economic and political		(-) Economic and political (-) Yields and product prices
Off-farm work	(+) Economic and political (+) Personal and farm business environment	(+) Personal and farm business environment (+) Yields and product prices (+) Financial situation (+) Input prices (+) Natural disaster	(+) Personal and farm business environment
Farm size	(-) Natural disaster	(+) Yields and product prices	
Net farm income	(-) Personal and farm business environment (+) Natural disaster	(-) Personal and farm business environment (-) Economic and political (-) Yields and product prices (-) Financial situation	(+) Personal and farm business environment
Farm location	(-) Economic and political (+) Personal and farm business environment (+) Natural disaster (+) Financial situation	(+) Personal and farm business environment (-) Economic and political (-) Yields and product prices (-) Financial situation (-) Natural disaster	(+) Personal and farm business environment (-) Natural disaster (+) Yields and product prices
Finance farm business	(+) Natural disaster (+) Financial situation	(-) Yields and product prices (+) Natural disaster	(+) Natural disaster (+) Yields and product prices
Annual household income	(+) Economic and political	(+) Economic and political (+) Financial situation (-) Natural disaster	
Household size	(+) Economic and political (+) Personal and farm business environment	(+) Personal and farm business environment (+) Economic and political (+) Financial situation	

Note: (+) and (-) represent positive and negative significant impact, respectively

<u>*For central region farmer group*</u>

- Female heads of farm households in the central region were more likely to perceive ‘personal and farm business environment’ and ‘natural disaster’ as more important sources of risk than did male household heads.

- Central region farmers with larger farm sizes were more concerned about 'yield and product prices' risks on farm.
- Central region farmers who had off-farm work and farmers who had lower net farm income perceived most risk components as important sources of risk on farm.
- Central region irrigated farmers perceived 'economic and political', 'yields and product prices', 'financial situation' and 'input prices' risks as highly important risks greater than did the farmers in rain-fed areas. The central region rain-fed farmers, in contrast, were more likely to be concerned about 'personal and farm business environment' risks.

For north-east region farmer group

- Young north-east farmers rated 'natural disaster' as more important source of risk than did the older farmers.
- Less experienced north-east farmers were likely to perceive 'economic and political' and 'yields and product prices' risks greater than did the more experienced farmers.
- North-east irrigated farmers were more concerned about 'natural disaster', whereas north-east rain-fed farmers perceived 'personal and farm business environment' and 'yields and product prices' as important sources of risk on farm.

Table 7.4 presents a summary of the results of the farmers' perceptions of risk management strategies and the socio-economic characteristics of the farmers in each group. The major findings are summarized as follows:

For all farmer group

- Female heads of farm households perceived 'off-farm income' as more important risk management strategy than did male household heads.
- More educated farmers, less experienced farmers, farmers who had off-farm work and farmers with smaller net farm income were more likely to perceive most risk strategy components as important strategies for managing their farm business risks.
- Farmers who had larger farm sizes were more highly concerned about a 'diversification' strategy than did farmers with smaller farm sizes.

- North-east farmers perceived ‘farm production and marketing management’, ‘diversification’ and ‘financial management’ as of greater importance than did the farmers in the central region.

For central region farmer group

- Female heads of farm households in the central region were more likely to be interested in ‘off-farm work’ and ‘diversification’ strategies than male household heads.
- More educated central region farmers and the central region farmers who have off-farm work perceived most risk management strategy components as important risk strategies.
- Central region farmers with larger households rated ‘farm production and marketing management’ and ‘off-farm income’ as more highly important risk strategies than did the smaller household farmers.
- Central region rain-fed farmers perceived the importance of ‘diversification’ and ‘financial management’ greater than did the irrigated farmers.

For north-east region farmer group

- Older north-east farmers considered ‘diversification’ more important than younger north-east farmers.
- Less experienced north-east farmers were more likely to perceive ‘diversification’, ‘preventive strategies’ and ‘off-farm income and marketing management’ as the important risk strategies than the more experienced farmers.
- North-east rain-fed farmers were more concerned about ‘off-farm income and marketing management’ and ‘diversification’ than the north-east irrigated farmers.

Table 7.4 Variables affecting perceptions of risk management strategy components

Variables	*All farmer group*	*Central region farmer group*	*North-east region farmer group*
Age			(+) Diversification
Gender	(-) Off-farm income	(-) Diversification (-) Off-farm income	
Education	(+) Farm production and marketing management (+) Diversification (+) Off-farm income	(+) Farm production and marketing management (+) Diversification (+) Off-farm income	(+) Off-farm income and marketing management
Farming experiences	(-) Farm production and marketing management (-) Diversification, (-) Financial management		(-) Preventive strategies (-) Off-farm income and marketing management (-) Diversification
Off-farm work	(+) Farm production and marketing management (+) Diversification (+) Off-farm income (+) Financial management	(+) Farm production and marketing management (+) Diversification (+) Off-farm income (+) Financial management	(+) Off-farm income and marketing management
Farm size	(+) Diversification		
Net farm income	(-) Farm production and marketing management (-) Diversification (-) Off-farm income (-) Financial management	(-) Farm production and marketing management	(+) Preventive strategies (+) Diversification
Farm location	(-) Farm production and marketing management (-) Diversification, (-) Financial management	(+) Diversification, (+) Financial management	(+) Off-farm income and marketing management (+) Diversification
Finance farm business	(-) Farm production and marketing management (-) Off-farm income		(-) Off-farm income and marketing management
Annual household income	(-) Diversification (+) Financial management	(-) Diversification	
Household size	(+) Farm production and marketing management	(+) Farm production and marketing management (+) Off-farm income	

Note: (+) and (-) represent positive and negative significant impact, respectively

In terms of farmers' attitude towards risk assessment, this research applied four alternative utility functional forms to evaluate their power in terms of risk aversion determination. A series of nine CE values was incorporated with nine utility values obtained from the ELCE method for each farmer in the central and north-east regions and they were examined across four functions using the nonlinear least square method. The findings verified that the classification of individual risk preferences were directly affected by the choice of utility function (see Appendix C). The results suggested that the negative exponential function performed best, compared with other utility function forms, in explaining farmers' risk behaviour. The negative exponential function classified all observed farmers in both regions as risk averse. The absolute risk aversion coefficients ($r_a(w)$) given by the negative exponential function ranged from 0.0000144, for the least risk averse, to 0.0001330, for the most risk averse, for the central region farmers and from 0.0000109 to 0.0012450 for the farmers in the north-east. An independent sample t-test was employed to examine the differences between the $r_a(w)$ of the farmers in both regions. The results indicated that the farmers in both regions had similar risk preferences.

The results regarding the influence of socioeconomic characteristics on the variation in risk preferences of the farmers in both regions showed that the less educated farmers and the farmers who had smaller households in the central region tended to exhibit more risk-averse behaviour (see Table 6.3). In contrast, the younger north-east farmers were likely to be more risk averse than the older farmers. The findings also indicated that there was a weak relationship between the net farm income, associated with wealth, and the risk aversion of the farmers in both regions.

A whole farm income model was employed to estimate the annual net farm income for each farming system planted by the farmers in the central and north-east regions. The results suggested that field crop-based and intensive rice production were the main farming systems for the central region rain-fed and irrigated farmers, respectively (see Tables 6.4 and 6.5). Multiple cropping and integrated crop-livestock production were the major cropping patterns for north-east rain-fed farmers, but a rice-intensive pattern was practiced by farmers in the north-east irrigated area (see Tables 6.6 and 6.7). The results of this research showed that the average net farm income in the 2008 crop year for the central region farmers was significantly greater than for farmers in the north-east. The average net farm income of the farmers in the irrigated area of both regions was significantly higher than for the rain-fed farmers (see Tables 6.8 and 6.9). Additionally, the use of large farm machinery and chemical fertilizer in agricultural production of the central region farmers was higher than the north-east region farmers.

The findings in this research provided a framework for SERF analysis to determine the most risk efficient farming systems for farmers in the central and north-east Thailand. A stochastic simulation model was used to estimate the probability distribution of net farm income for each alternative farming system. In terms of risk efficiency criteria, the risky farming systems were ranked using their certainty equivalent (CE) over the plausible ranges of $r_a(w)$ obtained from the negative exponential utility function. Table 7.5 summarizes the preferred farming systems based on the farmers' risk behaviour in the study areas. The SERF results indicated that maize followed by sorghum (CRFP4) was the most risk efficient farming system appropriate for the moderate and extremely risk averse rain-fed farmers in the central region. However, cassava (CRFP1) was preferred by the risk neutral central region rain-fed farmers. Furthermore, the results showed that wet rice followed by one crop of dry rice (CIFP1) was appropriate for the extremely risk averse central region irrigated farmers, but three lowland rice crops annually (CIFP2) was the most risk efficient farming system for the risk neutral and some of the moderately risk averse central region irrigated farmers.

The results suggested that wet rice and cassava with raising cattle (NRFP5) was the most risk efficient farming system appropriate for all risk aversion levels of north-east rain-fed farmers. The extremely risk averse north-east irrigated farmers preferred to grow two rice crops with raising cattle (NIFP3), but two rice crops and tomatoes (NIFP2) was appropriate for the risk neutral and some of the moderately risk averse north-east irrigated farmers.

Table 7.5 Preferred farming system based on the different farmers' risk behaviours in central and north-east Thailand

Study areas	*Farmers' risk behaviours*	
	Risk neutral	*Extremely risk averse*
Central region rain-fed area	Cassava (CRFP1)	Maize followed by sorghum (CRFP4)
Central region irrigated area	Three lowland rice crops annually (CIFP2)	Wet rice followed by one crop of dry rice (CIFP1)
North-east region rain-fed area	Wet rice and cassava with raising cattle (NRFP5)	Wet rice and cassava with raising cattle (NRFP5)
North-east region irrigated area	Two rice crops and tomatoes (NIFP2)	Two rice crops with raising cattle (NIFP3)

7.2 Implications of the research findings

The findings of this research have several important implications for academics, farmers and policy makers. *For academics*, this research provided empirical knowledge pertaining to farmers' risk behaviours and optimal farming systems that helped reduce risk for farmers in the central and north-east Thailand. The ELCE method yielded satisfactory results in terms of eliciting the CE for a series of risky outcomes to use as utility values. However, the response rates of the observed farmers in this elicitation technique were somewhat low (around 50 per cent in both regions). This was because some of the farmers declined to participate in a gambling style game due to religious beliefs. It has been documented by Hardaker, Huirne et al. (2004) that the ELCE technique will not work efficiently with persons who avoid gambling. Hence, this suggested that care should be taken when considering the selection of a technique to extract an individual's risk preferences.

The results showed that the farmers in both regions were averse to risk. This view supported Katikarn (1981) and Grisley and Kellog (1987) who argued that Thai farmers exhibit risk averse behaviour. The results further indicated that the choice of the utility function chosen by the researcher was crucial in predicting the farmers' risk behaviour. In this research, the negative exponential utility function could describe the observed farmers' risk preferences better than the cubic, power and expo-power functions. However, the results did not suggest that the negative exponential utility function might necessarily be the most appropriate and accurate utility function to estimate individuals' risk preferences in all other cases. Therefore, comparisons of the classification of individuals' risk preferences results from several alternative utility functions cannot be over emphasized.

Furthermore, the results clearly explained the influence of the farmers' socioeconomic characteristics on risk preferences. The non-wealth variables such as age, highest education level and household size significantly impacted the attitude of Thai farmers towards risk. However, the impact of the variable associated with wealth (net farm income) on risk aversion is ambiguous. This supported Binswanger (1980) who found a weak relationship between wealth and risk aversion among Indian farmers. Moscardi and Janvry (1977) and Binici et al. (2003) argued that understanding about farmers' risk attitudes and the factors that impacted their risk preferences was an effective tool to determine the technological packages and managerial strategies which were appropriate for the risk behaviour of the farmers. Therefore, the farmers' risk attitudes found in this research could be useful in the future research on whole farm decision making analysis that accounts for risk in Thailand.

The stochastic net farm income simulation model and the SERF framework were successfully implemented to investigate net returns and risk efficiency of alternative farming systems for the central and north-east farmers. According to the SERF results, field crop-based agriculture with alternative maize and sorghum (CRFP4) appeared to be the most risk efficient farming system suitable for the extremely risk averse central region rain-fed farmers. In contrast, intensive agriculture of wet rice and dry rice cultivation (CIFP1) was appropriate to reduce risk for the extremely risk averse central region irrigated farmers. The results also indicated that integrated crop-livestock farming systems were preferred by both the extremely risk averse north-east rain-fed and irrigated farmers. Wet rice followed by cassava with raising cattle (NRFP5) was preferred by the north-east rain-fed farmers, but two rice crops with raising cattle (NIFP3) was the most risk efficient farming system suitable for the north-east irrigated farmers.

Although the SERF results yielded useful information, some caution should be taken in interpreting them. First, the crop rotation data obtained from the observed central and north-east region farmers were grouped and treated as the optional farming systems in this research. It is undeniable that these risky options may not cover all patterns of farm production among all farmers in both regions. Thus, some potential cash crops such as soybean, cotton, jute, pineapple and pararubber as well as live-stock such as milking cows and swine were not used for comparison using risk efficiency criterion. Second, due to the lack of national and regional panel data regarding production costs at the farm-level from the OAE database, the average production costs of each farming system were estimated using information from the sampled farmers and then incorporated as the deterministic variable in the stochastic net farm income simulation model. Hence, an over- or underestimation of production costs given by the sampled farmers may have distorted the results. The cost of production estimation problems were also highlighted in Eggerman (2006) who claimed that the use of accurate production costs, especially from government databases, may improve the evaluation capacity of the stochastic net farm income simulation model. Finally, the impact of inflation on commodity prices was a major concern when investigating net farm income volatility (see Archer & Reicosky, 2009; Prato et al., 2010). Therefore, a sensitivity analysis was carried out; all prices for each individual crop were adjusted to 2008 baht using the consumer price index of Thailand. The results indicated that the net farm income volatilities for all the different farming systems declined when simulated using the inflation-adjusted commodity prices. This provided a clear evidence of the effects of commodity price inflation on the volatility of net returns.

For the farmers, the findings in this research can help farmers in deciding what appropriate risk efficient options they should choose. The most economically viable combinations of activities for farmers in each area were shown in the SERF analysis. The SERF results suggested that integrated crop-livestock farming systems were better options to enhance the income stability of rural poor farmers who lived in north-east Thailand. Raising small herds of cattle allowed for increased diversity of farm income could protect poor farmers against variations in income.

In contrast, the application of excessive chemical fertilizers, high wage costs and the high land rents of rice farmers in the central region irrigated area may have caused increases in total production costs. This would have a greater probability of generating a negative net farm income for intensive rice farming systems. Therefore, rice farmers in the central region should pay more attention to strengthening their cost control and management capacities.

For policy makers, the findings in this research yielded some suggestions to enhance the risk efficiency of farm income and improve the competitiveness of Thai farmers. Thailand's policy makers should recognize that any new or changed major policies that impacted the costs and returns of farmers, either positively or negatively, would also directly influence farmers' risk efficiency (Hardaker, Huirne, et al., 2004). Moreover, the risk behaviour of farmers was an important criterion that policy makers and other stakeholders must consider when developing agricultural policies, strategies and programmes. This is because, when adopting new policies and agricultural technologies, farmers depend on their particular risk perceptions and risk aversion (Anderson, 2003; Hardaker, Huirne, et al., 2004).

According to the results, farmers in both regions perceived 'unexpected variability of input prices' as the most important sources of risk on farm. It was not only the prices of chemical fertilizer but also the increase in wage rates and higher land rental rates that were the main factors that pushed the farm production costs upward. Over the past decade, the intervention of the Thai government in agricultural input policies had actually declined. The distribution of chemical fertilizers at reduced cost was the only scheme that the government organized to assist poor rural farmers. However, this scheme has recently been terminated due to limited government budget and this had no opportunities for the farmers to reduce production costs (see Isvilanonda & Bunyasiri, 2009).

The results also showed that the average total production costs of the central region farmers were nearly four times higher than that of the north-east farmers (see Tables 6.8 and 6.9). This resulted from the application of unnecessary chemical fertilizers, especially by the central region irrigated rice farmers. This view supported Isvilanonda and Bunyasiri (2009) who claimed that Thai farmers in the irrigated areas likely lacked knowledge about the appropriate level of fertilizer required to achieve an optimal yield. The authors also argued that the over use of chemical fertilizers and intensive use of land for rice cultivation may lead to accelerated degradation of soil fertility and continued decreases in productivity. Therefore, the development of sustainable soil management practices should be considered a priority to introduce to farmers nationwide. The best technical practices to increase soil organic carbon, such as minimum tillage, encouraging the use of organic manure and management of crop-pasture rotations, should be reviewed in order to retain soil fertility (see P. Smith & Powlson, 2004). Incentives should be provided to the farmers who adopt these soil management technologies. This would help farmers reduce the use of chemical fertilizers, reduce production costs and improve their risk efficiency.

The results indicated that the prices of rice and cassava were highly unstable and affected the farmers' net farm income volatility in both regions. This is similar to the results of the sources of risk perceptions, which showed 'unexpected variability of product prices' was the second most concern source of risk among the central and north-east region farmers. The Thai government operated a pledging scheme for the major cash crops such as wet rice, dry rice, cassava and maize (Department of Internal Trade, 2010). This scheme aimed to help farmers when commodity market prices fluctuated early in the harvesting season. However, the pledging scheme has been widely debated among policy experts, especially for rice (see Forssell, 2009; Hayami, 2007; Kajisa & Akiyama, 2004). The advantage of the rice pledging scheme is that farmers can obtain low-interest loans from the government when they decided to pledge their rice to the Bank of Agriculture and Agricultural Cooperatives (BAAC) at the pledging prices and the rice will be transferred to storage at the Public Warehouse Organisation (PWO). The government allowed the farmers to redeem and sell their rice in the market when market prices increased above the pledging prices. The pledging price was by a government announcement and generally the pledging period is approximately five to seven months each year (Isvilanonda & Bunyasiri, 2009). Conversely, some economists argued that the pledging scheme would have long-term negative impacts on the efficiency of the country's rice market and it seems that the management of the scheme is shaped by political forces (Forssell, 2009). The pledging scheme persuaded farmers to increase their production, but the quality of the products was frequently ignored (Chantanusornsiri, 2009). Some economists also suggested that the government should discontinue this highly-interventional price policy and should encourage farmers to sell their products using futures contracts to reduce the risk of price and income volatilities (Arunmas, 2008; Pratruangkrai, 2009). This challenged policy makers to create mechanisms to stabilize agricultural prices at levels that are economically reasonable for both farmers and consumers. In addition, the effects of price policies such as the pledging scheme should be assessed cautiously to improve the effectiveness of the scheme. Direct access to futures trading markets may perhaps be too complicated for smallholder farmers in Thailand. Hence, government agencies such as Ministry of Agriculture and Cooperatives, Ministry of Commerce and The Agricultural Futures Exchange of Thailand should try to find solutions that would increase small farmers' access to the futures market.

The research results showed that farmers in both regions perceived 'diseases and pests that affect plants and animals' and 'unexpected variability of yields' as important sources of on-farm risk. The government should continuously invest in agricultural research to improve new technologies that would enhance productivity and prevent epidemics of pests and diseases in crops and livestock. Genetic improvement for drought tolerance in rice and cassava should be created specifically for rain-fed agriculture in the north-east region. In addition, the development of high yielding rice and rice varieties resistant to diseases and pests is most appropriate for the irrigated environment in the central and north-east regions. However, it is important that the new technologies introduced to the farmers for productivity enhancement should not increase their farm production costs.

The development of a national agricultural crop insurance scheme should be one of the Thai government's priorities. Crop insurance is, theoretically, an efficient instrument in managing risks and can facilitate efforts to protect farmers from either the loss of their crops or farm income caused by natural disasters or the drops in commodities' prices. To date, a new crop insurance scheme for Thai farmers that has been operated by BAAC since 2008 is still in the pilot project stage (see Yimlamai, 2010). The government expects this crop insurance scheme will continue to develop to cover all farmers and crops countrywide in the near future (Commodity Online, 2010). The farmers' risk attitudes results in this research generate useful information for policy makers to develop the crop insurance scheme more quickly. Binici et al. (2003) and Wu (2007) argued that risk preference was one of the important factors that affected a farmer's decision to purchase or not purchase crop insurance. A risk averse farmer is more likely to purchase insurance to reduce his or her perceived risks. In addition, there are some obstacles that policy makers should consider for the successful implementation of the crop insurance schemes (see Abada, 2001; Hardaker, Huirne, et al., 2004; Yimlamai, 2010). First, the crop insurance model itself should not be too complicated because it could lead to high administrative costs for the scheme. Second, the appropriate insurance premiums and coverage accessibility under the scheme for each crop must be carefully considered. Low premiums may not always cover all the losses from the large-scale disasters, but the high insurance premiums will lead to increased farm production costs. Lastly, the government should promote the benefits of crop insurance schemes that could increase farmers' understanding and participation.

Alternatively, the government could encourage the adoption of the New Theory concept. This concept aimed to diversify farm activities to help improve self-sufficiency and stabilize farm income for small scale farmers (see Section 2.3 for details). The results suggested that the New Theory would be beneficial and appropriate for farmers in the rain-fed environment, especially in the north-east. The results also showed that rain-fed farmers in both regions advocated production diversification strategies that would reduce risk on their farms significantly more than irrigated farmers. In addition, limited farm size, shortage of financial investment and lack of agricultural labour are important potential barriers for central and north-east region farmers in undertaking on-farm diversification. Therefore, the government should pay more attention to solving these barriers. More public investment in agricultural water resources development in the north-east should be carried out. This would increase overall agricultural production capacity, increase productivity and enhance farm revenue. In addition, this would help to reduce net farm income volatility for the rural poor north-east farmers.

Strengthening the role of farmer groups or cooperatives should be considered as part of agricultural risk reduction policies in Thailand. This is because farmers' groups or cooperatives can help farmers to improve their negotiating power. Higher product prices and lower input prices can then be achieved more easily, due to economies of scale, than for individual farmers (Hardaker, Huirne, et al., 2004). As of January 2010, there were over 3,761 primary agricultural cooperatives nationwide but only some are successfully operating their businesses (Cooperative Promotion Department, 2010). Therefore, appropriate measures should be designed to enhance the efficiency of the primary agricultural cooperatives, while strictly maintaining the cooperative principles. In the future, primary agricultural cooperatives may act as the representative of smallholder farmers in accessing futures trading.

7.3 Research limitations

There are a number of limitations in this research related to sample selection, data and estimation techniques. These include:

- The quality and accuracy of the collected data need attention. This is because data collection was conducted during January and April 2009 and by then some farmers had already started a new growing season. However, the farmers were asked to provide information of their farm rotations, farm income and production costs on the previous crop (crop year 2008). For this reason the farmers might have given some incorrect information, which may have distorted the SERF results in this research.
- The ELCE interview in this research was performed by the researcher and trained research assistants. However, during the interview process, the questions and/or the interviewers might sometimes have put pressure on the farmers to choose particular alternatives. This may have led to biased answers from the farmers that would have a direct effect on the farmers' risk attitude estimations.
- The sources of risk and risk management strategies perceptions were examined using structured questionnaires. The lists of sources of risk and risk management strategies

provided may not have covered all of the sources of risk that Thailand farmers confronted or the risk strategies they used on farm.

- The historical data on market prices for each individual crop at the provincial level, from the 1998 to 2008, employed in this research were collected from the OAE database. However, there are many forms of government intervention that subsidized the price of major agricultural commodities in Thailand, such as rice, cassava and sugarcane. The impacts from these pricing schemes have a substantial affect on market prices and market conditions for agricultural products. This may also have affected the risk efficiency of the Thai farmers. Unfortunately, this research cannot provide evidence to prove this claim.

- It is necessary to be cautious when interpreting the results of the association between the farmers' characteristics and the sources of risk and risk strategy components. This is due to the low coefficients of determination (R^2) of most regression models. This research also encountered similar problems of low R^2 when the relationship of the farmers' risk aversion and the wealth and non-wealth characteristics were examined. However, the low R^2 may be due to the variation in the perceptions of sources of risk and risk strategies which differed from farmer to farmer between rain-fed and irrigated areas of the central and north-east regions. In addition, the data provided for the regression analysis in this study were cross-sectional data which exhibited lower R^2 compare to time series data (Reisinger, 1997).

7.4 Recommendations for future research

The results in this research indicated that the SERF is a useful theoretical framework to investigate and compare net farm income associated with risk for the alternative farming systems over the differences in risk behaviour of farmers. Further research of economic risk analysis of farms in Thailand can focus on evaluating the economic risk efficiency of the alternative on-farm production strategies using SERF such as the organic versus conventional farming (see Lien, Hardaker, et al., 2007; Tzouramani, Karanikolas, & Alexopoulos, 2008), the use of different tillage systems versus no-tillage (see Archer & Reicosky, 2009; Ascough II, Fathelrahman, Vandenberg, Green, & Hoag, 2009; Pendell et al., 2007; Watkins, Hill, & Anders, 2008), the appropriate tree replanting systems which would help pararubber and eucalyptus farmers in replanting or replacement decision making (see Lien, Stordal, et al., 2007), the use of weed and pest management options on farm (see Upadhyay, Smith, Clayton, Harker, & Blackshaw, 2006) and the optimal farming practices that contribute to less global warming and climate change (see Prato et al., 2010).

The SERF framework can also be employed to quantify the appropriate marketing strategies, such as forward contracts and other marketing alternatives, which could help Thai farmers to cope with market risks (see Donnelly & Noel, 2006; Elrod et al., 2008). The risk efficient farm investment strategies might be usefully investigated for large and small scale Thai farmers (see Nartea & Webster, 2008). It is also interesting to incorporate agricultural policy variables into the stochastic simulation model to examine the impacts of those policies in minimizing farmers' income volatility (see Archer & Kludze, 2006; Grove & Oosthuizen, 2010). Future researchers should carefully consider how to obtain access to data sources in Thailand and the quality of the data given by those providers.

In future, research can be repeated or extended to estimate the most risk efficient farming systems for the northern and southern region farmers. This is because the types of crop grown, weather and geographical conditions and cost of production are much different among the farmers in the four main regions. This would improve the comprehensive understanding pertaining to economic risk efficiency between different farming systems in Thailand. Moreover, this may provide useful information for the Thai government to develop an agricultural production zoning policy that can help minimize production and marketing risks for farmers.

In terms of the farmers' risk preference measurement, future research can employ other methods, such as the experimental method (EM) and observed economic behaviour (OEB), to elicit individual utility functions and estimate his or her attitude toward risk (see Section 3.3 for details). Hardaker and Lien (2005) argue that assessing the validity and reliability of the individual risk preferences is a critical task because the errors and bias in the analyses could mislead the results.

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Appendix A

Questionnaire

Lincoln University
Te Whare Wānaka o Aoraki

Commerce Division
PO Box 84, Lincoln University,
Canterbury 7647, New Zealand
Telephone 64 3 325-2811
Facsimile 64 3 325-3847
www.lincoln.ac.nz

October 11, 2008

Dear Sir/Madam:

You are invited to participate in a survey on risk analysis of smallholder farmers in Central and North-east Thailand. This is a part of my requirement in fulfilling the degree of PhD in Agricultural Economics at Lincoln University, New Zealand. The aims of this research are to investigate risk factors affecting smallholder farmers' net revenue and estimate the risk efficient farming systems for smallholder farmer in each region.

Your name has been randomly selected from a list of farmers from your provincial office of agriculture. Your participation in this research involve an interview by a researcher on a series of questions on general farm household information, farming system, source of risk on your farm and your risk preferences as a farmer. If you are willing to participate, the interviewing time will take approximately 25 to 35 minutes to complete.

The research has been approved by the Human Ethics Committee of Lincoln University. Complete confidentiality is assured in this survey. All responses will be aggregated for research analyses, and hence, no individual will be identified. This research is completely voluntary in nature and you are free to decide not to participate or to withdraw at anytime. If you participate in the interview, however, it will be understood that you are 18 years of age or older and have consented to participate in the research and consent to publication of the results of the research with the understanding that anonymity will be preserved.

If you have any questions or concerns, please feel free to contact me at telephone numbers 0-4336-4638 (in Thailand) or +6433253838 ext 8823 (in New Zealand) or by sending an email to adittos2@lincoln.ac.nz. Alternatively, you may contact my research supervisors Dr. Christopher Gan and/or Dr. Gerry Nartea at telephone numbers +6433253838 (ext 8155 and/or 8368 respectively) or by sending an email to Dr. Gan at ganc1@lincoln.ac.nz or Dr. Nartea at narteag@lincoln.ac.nz.

Thank you for your time and participation in this research.

Best regards,

Satit Aditto
PhD Candidate
Commerce Division
Lincoln University

Research Supervisors:

Dr. Christopher Gan
Associate Professor
Commerce Division

Dr. Gerry Nartea
Senior Lecturer
Commerce Division

This project has been reviewed and approved by Lincoln University Human Ethic Committee.

Consent Form

Name of Project: ***Risk Analysis of Smallholder Farmers in Central and North-east Thailand***

I have read and understood the description of the project. On this basis I agree to participate as an interviewee in the project, and I consent to publication of the results of the interview with the understanding that anonymity will be preserved. I understand also that I may at any time to stop and withdraw from the interview.

Name: ____

Signed: ______________________________ Date: ____________

Lincoln University
Te Whare Wānaka o Aoraki

INTERVIEW QUESTIONNAIRE

Risk Analysis of Smallholder Farmers in Central and North-east Thailand

Introduction: You are invited to participate in a survey that is a part of my Doctoral research project at Lincoln University, New Zealand. This research aims to identify the factors affecting risk of smallholder farmers in Central and North-east Thailand.
For each question with brackets provided, please check your answer(s); otherwise, please follow the instructions given to answer the questions.

Date of interview _____/_____/ 2008 Questionnaire Number: ☐

Farm Location : 1) Central-Irrigated area ☐
2) Central-Rain fed area ☐
3) North-east-Irrigated area ☐
4) North-east-Rain fed area ☐

Village (Name) ______________________________
District (Name) ______________________________
Province (Name) ______________________________

Section A: General farm information

1. How many rais of land do you farm? ________________ rais

2. What is the ownership status of your land?
☐1. Owner-self operated
☐2. Lease-self operated
☐3. Tenant
☐4. Other______________________

3. How did you finance your farming business operation over the last 2 years?
☐1. Yes ☐2. No, ***please go to Q8***

4. Please identify the sources of your farm credit *(check all that apply)*
☐1. Borrow from Bank of Agriculture and Agricultural Cooperative (BAAC)
☐2. Borrow from Commercial Bank
☐3. Borrow from Cooperative
☐4. Borrow Village funds
☐5. Borrow from Relatives/friends
☐6. Personal funds
☐7. Other(s) please specify ___________________________________

5. What is the duration of your farm credit?

- ☐ 1. Less than 1 year
- ☐ 2. Between 1 – 2 years
- ☐ 3. Between 2 – 3 years
- ☐ 4. Greater than 3 years
- ☐ 5. Other(s) please specify ____________________________________

6. What is your outstanding loan the last year (2007/2008 season)?

- ☐ 1. Fully paid
- ☐ 2. Under 30,000 baht
- ☐ 3. 31,000-50,000 baht
- ☐ 4. 51,000-70,000 baht
- ☐ 5. 71,000-90,000 baht
- ☐ 6. Over 91,000 baht
- ☐ 7. Other(s) please specify ____________________________________

7. What percentage of your loan is used for:

1. On-farm activities (for example to purchased farm equipment, seed or fertilizer) __________ %
2. Household expenses (for example spent for food, clothing or personnel expenses) __________ %

8. What are the on-farm assets you owned?

Items	Number	Year of Purchased	Purchased value (baht)	Useful life (Year)	Remarks (If some assets are use in household and on farm such as motorcycle, truck etc. *please state the percentage of that asset is used for farm*)
A) Land & Farm Buildings					
1. Land Land tax ________(baht/Rai) Rental _____(baht/Rai/Annum)					
2. Storage cottages					
3. Tractor sheds					
4. Cowsheds					
5. Mushroom house					
6. Shade house					
7. Fish cages					
8. Other________________					
B) Farm Machinery					
1. Four-wheel tractors					
2. Hand tractors					
3. Trailers					
4. Rotary tillers					
5. Rotary weeders					
6. Harvesters					
7. Irrigation pumps					
8. Other________________					
C) Farm Tools					
1. Ploughs					
2. Harrows					
3. Diggers					
4. Sprayers					
5. Other________________					
D) Vehicles					
1. Motorcycle					
2. Car or truck					
3. Other________________					

Section B: Farming System

The questions below relate to agricultural activities on your farms. For each question with brackets or box provided please tick your answer(s). Otherwise please follow the instructions given to answer the questions.

1. What kinds of agricultural activities have you raised on your farm over the last year? *(Check all that apply to **all kind of the activities on your farm** and **complete all questions in each choices** and then go to Section C)*

- ☐ 1. **Rice**, ***please go to Q2***
- ☐ 2. **Arable Crops** (All types of arable crops e.g. maize, cassava, sugarcane, soybeans) ***please go to Q3***
- ☐ 3. **Horticulture** (All types of horticultural production including fruit, vegetables and flowers) ***please go to Q4***
- ☐ 4. **Forestry** (Plantations of trees including rubber, eucalyptus and etc.) ***please go to Q5***
- ☐ 5. **Livestock** (All types of commercial animal production e.g. cattle, pigs, poultry, milking cows) ***please go to Q6***
- ☐ 6. **Fish** (All types of freshwater fish production) ***please go to Q7***

2. Rice *(**Do not include** rice production for household consumption)*

2.1 **During the 2007/08 season**, how many cropping of rice did you grow on your farm?

- ☐ 1. Single crop per year (wet season rice)
- ☐ 2. Two crops per year (wet season rice and dry season rice)
- ☐ 3. Three crops per year (wet season rice and two crops of dry season rice)

2.2 Below is a series of statements pertaining to cropping pattern, planted area, total production sold and price for rice in the past cropping season;

a. How many rais of land did you grow rice for **the 2007/08 season**?
b. What is the total rice production sold (in tonnes) for **the 2007/08 season**?
c. What is the price of rice sold (in baht/tone) for **the 2007/08 season**?

(If any area is used for growing rice twice or three times in a year please record them as well)

	Planted Area *(Rai)*	Total Production *(Tonnes)*	Total Production sold *(Tonnes)*	Price for rice *(Baht/Tonne)*
Single season (Start from _________(month) to ________ (month))				
Wet season rice				
Second season (Start from _________(month) to ________ (month))				If no tick here ☐
Dry season rice				
Third season (Start from _________(month) to ________ (month))				If no tick here ☐
Dry season rice				

2.3 What is your total rice production cost (in baht) for **the 2007/08 season**?
(If the farmer grows rice twice or three times in a year please record the production cost in each season as well)

Items	Single season	Second season If no tick here ☐	Third season If no tick here ☐
Total land preparation cost: *For example* cost of hired labour, hired equipment, repairs and maintenance and fuel.			
Total planting cost: *For example* cost of seeds, fertilisation, pesticides, herbicides, hired labour to do planting or replanting, spraying and irrigation.			
Total harvesting cost: *For example* cost of hired harvester or combine, drying, hired labour, fuel, loading and transportation.			
Total production cost			

3. Arable Crops *(**Do not include** crops production for household consumption)*

3.1 **During the 2007/08 season**, how many times did you grow arable crops?
- ☐ 1. Once a year
- ☐ 2. Twice a year
- ☐ 3. Three times a year

3.2 Below is a series of statements pertaining to cropping pattern, planted area, total production sold and price for each arable crop in the past cropping season;

a. How many rais of land did you grow for each arable crop for **the 2007/08 season**?
b. What is the total production of each arable crop sold (in tonnes) for **the 2007/08 season**?
c. What is the price of each arable crop sold (in baht/tone) for **the 2007/08 season**?

(If any area is used for growing arable crop twice or three times in a year please record them as well)

Type of arable crop	Planted area *(Rai)*	Total production *(Tonnes)*	Total production sold *(Tonnes)*	Price for crop *(Baht/Tonne)*
Single season (Start from _________(month) to ________ (month))				
Cassava				
Maize				
Sugarcane				
Soybeans				
Other arable crops (please specify)				
Second season (Start from _________(month) to ________ (month))				If no tick here ☐
Cassava				
Maize				
Sugarcane				
Soybeans				
Other arable crops (please specify)				

Type of arable crop	Planted area *(Rai)*	Total production *(Tonnes)*	Total production sold *(Tonnes)*	Price for crop *(Baht/Tonne)*
Third season (Start from _________(month) to ________ (month))				
Cassava				
Maize				
Sugarcane				
Soybeans				
Other arable crops (please specify)				

3.3 What is your total arable crop production cost (in baht) for **the 2007/08 season**?
(If the farmer grows arable crop twice or three times in a year please record the production cost in each season as well)

Items	**Single season**	**Second season** If no tick here ☐	**Third season** If no tick here ☐
Total land preparation cost: *For example* cost of hired labour, hired equipment, repairs and maintenance and fuel.			
Total planting cost: *For example* cost of seeds, fertilisation, pesticides, herbicides, hired labour to do planting, spraying and irrigation.			
Total harvesting cost: *For example* cost of hired harvester or combine, drying, hired labour, fuel, loading and transportation.			
Total production cost			

4. Horticulture *(**Do not include** horticulture production for household consumption)*

4.1 Vegetables

If no tick here ☐

4.1.1 **During the 2007/08 season**, how many times did you grow vegetables?

☐1. Once a year
☐ 2. Twice a year
☐ 3. Three times a year

4.1.2 Below is a series of statements pertaining to cropping pattern, planted area, total production sold and price for each vegetable on your farm in the past cropping season;

a. How many rais of land did you grow each vegetable for **the 2007/08 season**?
b. What is the total production of each vegetable sold (in kilograms) for **the 2007/08 season**?
c. What is the price of each vegetable sold (in baht/kg.) for **the 2007/08 season**?

(If any area is used for growing vegetable twice or three times in a year please record them as well)

Type of vegetable	Planted area *(Rai)*	Total production *(Kilograms)*	Total production sold *(Kilograms)*	Price for vegetable *(Baht/Kg)*
Single season (Start from _________(month) to ________ (month))				
Second season (Start from _________(month) to ________ (month))				If nil tick here
Third season (Start from _________(month) to ________ (month))				If nil tick here

4.1.3 What is your total vegetable production cost (in baht) for **the 2007/08 season**?
(If the farmer grows vegetable twice or three times in a year please record the production cost in each season as well)

Items	**Single season**	**Second season** If no tick here	**Third season** If no tick here
Total land preparation cost: *For example* cost of hired labour, hired equipment, repairs and maintenance and fuel.			
Total planting cost: *For example* cost of seeds, fertilisation, pesticides, herbicides, hired labour to do planting or weeding, spraying and irrigation.			
Total harvesting cost: *For example* cost of hired labour for harvesting, loading and transportation.			
Total production cost			

4.2 Fruits

If no tick here ☐

4.2.1 Below is a series of statements pertaining to planted area, total production sold and price for each fruit on your farm in the past cropping season;

a. How many rais of land did you grow each fruit for **the 2007/08 season**?
b. What is the total production of each fruit sold (in kilograms) for **the 2007/08 season**?
c. What is the price of each fruit sold (in baht/kg.) for **the 2007/08 season**?

Type of fruit	Planted area *(Rai)*	Total production *(Kilograms)*	Total production sold *(Kilograms)*	Price for fruit *(Baht/Kg)*
Bananas				
Mangoes				
Papaya				
Other fruits (please specify)				

4.2.2 What is your total fruit production cost (in baht) for **the 2007/08 season**?

Items	**Cost (baht)**
Total land preparation cost: *For example* cost of hired labour, hired equipment, repairs and maintenance and fuel.	
Total planting cost: *For example* cost of seeds, fertilisation, pesticides, herbicides, hired labour to do planting or weeding, spraying and irrigation.	
Total harvesting cost: *For example* cost of hired labour for harvesting, loading and transportation.	
Total production cost	

4.3 Cut flower

If nil tick here ☐

4.3.1 What kind of the cut flower production system on your farm?

☐ 1. Open field (outdoor)
☐ 2. Shade house
- Shade house size _____________ square meters

☐ 3. Insect-prevent house (Net house)
- Net house size _____________ square meters

4.3.2 Below is a series of statements pertaining to planted area, total production sold and price of each cut flower on your farm in the past cropping season;

a. How many rais of land did you grow each cut flower for **the 2007/08 season**?
b. What is the total production of each cut flower sold (in kilograms) for **the 2007/08 season**?
c. What is the price of each cut flower sold (in baht/kg.) for **the 2007/08 season**?

Type of cut flower	Planted area *(Rai)*	Total production sold *(Kilograms)*	Price for flower *(Baht/Kg)*
Orchids			
Roses			
Lotus			
Marigold			
Champaca			
Jasmine			
Other cut flowers (please specify)			

Remarks: Cut orchids approx 40 stems/kg and other cut flowers approx 35 stems or flowers/kg (Department of Agricultural Extension, 2008)

4.3.3 What is your total cut flower production cost (in baht) for **the 2007/08 season**?

Items	**Cost (baht)**
Total land preparation cost: *For example* cost of hired labour, hired equipment, repairs and maintenance and fuel.	
Total planting cost: *For example* cost of seeds, fertilisation, pesticides, herbicides, hired labour to do planting or weeding, spraying and irrigation.	
Total harvesting cost: *For example* cost of hired labour for harvesting, loading and transportation.	
Total production cost	

5. Forestry

5.1 Rubber

If no tick here ☐

5.1.1 How many rais of rubber did you planted on your farm? ___________ Rai

5.1.2 What is the total rubber production and sales **during the 12 months**?

Quantity of rubber produced per month *(kg./month)*	
How many months of rubber sold in last year?	
Price per unit of rubber sold *(baht/kg.) (Please estimate the average prices)*	
Total income from rubber *(baht)*	

5.1.3 What is your total rubber production cost (in baht) **during the 12 months**?

Items	**Cost (Baht)**
Total land preparation cost: *For example* cost of hired labour, hired equipment, repairs and maintenance and fuel.	
Total planting cost: *For example* cost of fertilizer, pesticides, herbicides, hired labour to do weeding and cutting and irrigation.	
Total harvesting and processing cost: *For example* cost of hired labour for harvesting and processing rubber, electricity, chemicals for processing rubber, loading and transportation.	
Total production cost	

5.2 All other forest production

If no tick here ☐

5.2.1 Below is a series of statements pertaining to planted area, total production sold and price of each forest production on your farm during the last 12 months:

a. How many rais of land did you plant each type of forest **during the 12 months**?

b. What is the total production of each type of forest sold (in tones) **during the 12 months**?

c. What is the price of each forest production sold (in baht/tone) **during the 12 months**?

Type of tree	Planted area *(Rai)*	Total production sold *(Tonnes)*	Price for tree *(Baht/Tonne)*
Eucalyptus			
Conifer			
Other tree (please specify)			

5.2.2 What is your total forest production cost (in baht) **during the 12 months**?

Items	**Cost (Baht)**
Total land preparation cost: *For example* cost of hired labour, hired equipment, repairs and maintenance and fuel.	
Total planting cost: *For example* cost of fertilizer, pesticides, herbicides, hired labour to do weeding and cutting and irrigation.	
Total harvesting cost: *For example* cost of hired labour for harvesting, loading and transportation.	
Total production cost	

6. Livestock *(**Do not include** animal production for household consumption)*

6.1 Below is a series of statements pertaining to animal stocks, production sold and income from each animal on your farm during the last 12 months:

a. What is the total number of each livestock raised on your farm **as at 31 August 2008**?

b. What is the number of each animal sold **during the 12 months**?

c. How much is the income from each animal sold (in baht) from your farm **during the 12 months**?

I) Beef cattle — If no tick here ☐

No. of heads *(as at 31 August 2008)*	**No. of beef cattle sold** *(during the 12 months)*	**Income from beef cattle** *(baht)* *(please estimate)*

II) Buffaloes — If no tick here ☐

No. of heads *(as at 31 August 2008)*	**No. of buffaloes sold** *(during the 12 months)*	**Income from buffaloes** *(baht)* *(please estimate)*

III) Hogs — If no tick here ☐

No. of heads *(as at 31 August 2008)*	**No. of hogs sold** *(during the 12 months)*	**Income from hogs** *(baht)* *(please estimate)*

IV) Dairy cow — If no tick here ☐

	No. of heads *(as at 31 August 2008)*	**No. of animals sold** *(during the 12 months)*	**Income from animals** *(baht)* *(please estimate)*
Dairy cows			
Dry cows			
Heifers			
Male calves			
Female calves			

What is the milk production and sales **during the 12 months**? (***Do not include*** *milk for household consumption)*

Quantity of milk produced *(kg./month)*	
Quantity of milk sold *(kg./month)*	
How many months of milk sold in last year?	
Price per unit of milk sold *(baht/kg.) (Please estimate the average prices)*	
Total income from milk *(baht)*	

V) Poultry — If no tick here ☐

	No. of heads *(as at 31 August 2008)*	**No. of animals sold** *(during the 12 months)*	**Income from animals** *(baht) (please estimate)*
Broilers			
Hens			
Native chickens			
Ducks			

What is the production of **chicken eggs** and sales **during the 12 months**? (**Do NOT include** fertilised eggs and eggs for farm household consumption)

How many dozen of chicken eggs sold? *(dozen)*	
Price for dozen of chicken eggs sold *(baht/dozen) (Please estimate the average prices)*	
Total income from chicken eggs *(baht)*	

What is the production of **duck eggs** and sales **during the 12 months**? (**Do NOT include** fertilised eggs and eggs for farm household consumption)

How many dozen of duck eggs sold? *(dozen)*	
Price for dozen of duck eggs sold *(baht/dozen) (Please estimate the average prices)*	
Total income from duck eggs *(baht)*	

VI) All other Livestock — If no tick here ☐

Other livestock (please specify)

No. of heads *(as at 31 August 2008)*	**No. of animals sold** *(during the 12 months)*	**Income from animals** *(baht) (please estimate)*

6.2 What is your total animal production cost (in baht) for **the last 12 months**?

Items	**Cost (baht)**
Total feed cost: including roughage and concentrate feed	
Total other costs: *For example* cost of breeding stock, veterinary supplies and services, hired labour, electricity, fuel, transportation and marketing expenses.	
Total production cost	

7. Fish (***Do not include*** *fish production for household consumption)*

7.1 What kind of the fish production system did you have on your farm?

☐ 1. Pond system
- Pond size _____________ square meters
- Number of ponds __________

☐ 2. Paddy-field system

☐ 3. Ditch system

☐ 4. Cage system
- Cage size _____________ square meters
- Number of cages __________

7.2 Below is a series of statements pertaining to total production and income from each fish on the farm during the 12 months:

a. What is the total production of each fish sold (in kilograms) from your farm **during the 12 months**?

b. What is the income from each fish sold (in baht) **during the 12 months**?

Type of fish	No. of fish sold *(Kilograms)* *(during the 12 months)*	Income from fish *(Baht)* *(please estimate)*
Nile tilapia		
Stripped catfish		
Walking catfish		
Sepat siam		
Other fish species (please specify)		

7.3 What is your total fish production cost (in baht) for **the last 12 months**?

Items	**Cost (baht)**
Total feed cost:	
Total other costs: *For example* cost of fish breeding stock, irrigation hired labour, electricity, fuel, transportation and marketing expenses.	
Total production cost	

Section C: Sources of Risk

Below is a series of statements pertaining to sources of farm risks. Please circle the number, which most accurately reflects how important the risks are to your farming operation

How important are the following risks to your farming operation?	Extremely important	Important	Quite important	Somewhat important	Not important
Risk from deficiency in rainfall causing drought	5	4	3	2	1
Risk from excess rainfall	5	4	3	2	1
Risk from natural disasters such as heat, fire, flood, storm	5	4	3	2	1
Risk from diseases and pests that affect plants and animals	5	4	3	2	1
Risk from unexpected variability of yields	5	4	3	2	1
Risk from unexpected variability of product prices	5	4	3	2	1
Risk from unexpected variability of input prices	5	4	3	2	1
Risk from changes in interest rates	5	4	3	2	1
Risk from high level of debt	5	4	3	2	1
Risk from changes in the world economic and political situation	5	4	3	2	1
Risk from changes in Thailand’s economic and political situation	5	4	3	2	1
Risk from changes in national government laws and policies	5	4	3	2	1
Risk from changes in land prices	5	4	3	2	1
Risk from accidents or problems with health	5	4	3	2	1
Risk from changes in family situation such as marital status, inheritances, etc.	5	4	3	2	1
Risk from problems with hired labour and contractors	5	4	3	2	1
Risk from theft	5	4	3	2	1
Risk from being unable to meet contracting obligations	5	4	3	2	1
Risk from changes in technology and breeding	5	4	3	2	1

Section D: Risk Management

Below is a series of statements pertaining to risk management option. Please circle the number, which most accurately reflects the importance of risk management options in managing your farm operational risks. Please also circle YES if you use the risk management option and NO if you do not use it.

How important are the following risk management option <u>in your farm operation</u>?	Extremely important	Important	Quite important	Somewhat important	Not important	**Do you use this risk management method?**	
Having diversified crop, animal or other enterprises on your small farm	5	4	3	2	1	1.YES	2.NO
Storing feed and/or seed reserves	5	4	3	2	1	1.YES	2.NO
Planting several varieties of crops	5	4	3	2	1	1.YES	2.NO
Apply pests and diseases program	5	4	3	2	1	1.YES	2.NO
Have a farm reservoir for water supplies in dry season	5	4	3	2	1	1.YES	2.NO
Purchase farm machinery to replace of labour	5	4	3	2	1	1.YES	2.NO
Able to adjust quickly to weather, price and other adverse factors	5	4	3	2	1	1.YES	2.NO
Selection of crop and/or animal varieties with low price variability	5	4	3	2	1	1.YES	2.NO
Spreading sale over several time period	5	4	3	2	1	1.YES	2.NO
Use forward contracts	5	4	3	2	1	1.YES	2.NO
Obtaining market information on prices forecast and trends	5	4	3	2	1	1.YES	2.NO
Holding cash and easily converted cash assets	5	4	3	2	1	1.YES	2.NO
Reduce debt level	5	4	3	2	1	1.YES	2.NO
Leasing farm machinery rather than owning them	5	4	3	2	1	1.YES	2.NO
Working off farm to supplement net farm income	5	4	3	2	1	1.YES	2.NO
Investing in non-farm investment/business	5	4	3	2	1	1.YES	2.NO

Section E: Farmer's Utility Elicitation

This section attempts to measure respondent's risk aversion preferences. A series of hypothetical risky farm outcomes will be use to derive the farmer's utility function.

Below is a series of risky farm outcomes. As a farmer, you face prospectively large number of choices in different cropping systems. Each cropping system will generate certain risky outcomes. Please specify the sure sum of money that makes you indifferent between two risky farm outcomes with equal probability given below.

Situation I

If you are given a choice between

a) a lottery ticket and
b) a sure sum of money;

The lottery ticket will gives you the chance to win either 100,000 baht or nothing (0 baht). If the sure sum of money is 40,000 baht. Would you choose the lottery ticket or the 40,000 baht?

Lottery Ticket		Cash
Probability		
50%	**100,000 baht**	
		40,000 baht
50%	**0 baht**	

Note:

a) If the farmer chooses the cash, we pose the same question but lower the cash amount (e.g. 35,000 baht)
b) If the farmer chooses the lottery ticket, we pose the same question but increase the cash amount (e.g. 45,000 baht)
c) We will proceed with this line of questioning until the farmer becomes indifferent between taking the lottery ticket or taking the cash amount.
d) Once we have found the cash amount that will make the farmer indifferent (e.g. 30,000 baht) we present to the farmer another lottery and repeat the procedure from Scenario I.

Lottery Ticket		Cash
Probability		
50%	**30,000 baht**	
		17,000 baht
50%	**0 baht**	

Note:

If the farmer is indifferent between this new lottery and for example 15,500 baht then we present to the farmer another lottery and repeat the procedure.

Lottery Ticket			Cash
Probability			
50%	**15,500 baht**		
			11,000 baht
50%	**0 baht**		

Note:
If the farmer is indifferent between this new lottery and for example 9,500 baht then we present to the farmer another lottery and repeat the procedure.

Lottery Ticket			Cash
Probability			
50%	**9,500 baht**		
			5,000 baht
50%	**0 baht**		

Note:
Once we have found the cash amount that will make the farmer indifferent between the new lottery and the cash we proceed to Scenario II.

Situation II

If you are given a choice between
a) a lottery ticket and
b) a sure sum of money

The lottery ticket will give you the chance to win either 100,000 baht or 30,000 baht. If the sure sum of money is 55,000 baht. Would you choose the lottery ticket or the 55,000 baht?

Lottery Ticket			Cash
Probability			
50%	**100,000 baht**		
			55,000 baht
50%	**30,000 baht**		

Note:
a) If the farmer chooses the cash, we pose the same question but lower the cash amount (e.g. 52,000 baht)
b) If the farmer chooses the lottery ticket, we pose the same question but increase the cash amount (e.g. 57,000 baht)

c) We will proceed with this line of questioning until the farmer becomes indifferent between taking the lottery ticket or taking the cash amount.
d) Once we have found the cash amount that will make the farmer indifferent (e.g. 60,000 baht) we present to the farmer another lottery and repeat the procedure from Scenario II.

Lottery Ticket		**Cash**
Probability		
50%	**100,000 baht**	
		70,000 baht
50%	**60,000 baht**	

Note:
If the farmer is indifferent between this new lottery and for example 75,000 baht then we present to the farmer another lottery and repeat the procedure.

Lottery Ticket		**Cash**
Probability		
50%	**100,000 baht**	
		85,000 baht
50%	**75,000 baht**	

Note:
Once we have found the cash amount that will make the farmer indifferent between the new lottery and the cash then we finish the process in this section.

For staff use only:

Situation	Number	Amount (baht)
Situation I	1	
	2	
	3	
	4	
Situation II	5	
	6	
	7	

Section F: Socio-Economic Profile of Farmers

1. What is your gender?
   ☐ 1. Male ☐ 2. Female

2. Which is your age group?
   ☐ 1. Less than 30 years old ☐ 2. 31-40 years old ☐ 3. 41-50 years old
   ☐ 4. 51-60 years old ☐ 5. Over 60 years old

3. What is your marital status?
   ☐ 1. Single/Never married ☐ 2. Married
   ☐ 3. De factor relationship ☐ 4. Divorce/Separated

4. What is your highest educational qualification?
   ☐ 1. No education ☐ 2. Primary school (grade 1-6)
   ☐ 3. Secondary school (grade 7-12) ☐ 4. Vocational training
   ☐ 5. Bachelor degree ☐ 6. Postgraduate degree
   ☐ 7. Other (s) please specify ____

5. How many years have you been farming?
   ☐ 1. 10 years or less ☐ 2. 11-20 years ☐ 3. 21-30 years
   ☐ 4. 31-40 years ☐ 5. Over 40 years

6. How many children do you have?
   ☐ 1. None ☐ 2. 1 ☐ 3. 2
   ☐ 4. 3 ☐ 5. More than 4
   ☐ 6. Other (s) please specify ____

7. The number of people living in your household is (please state):
   ________________persons

8. Do members of your family work on your farm?
   ☐ 1. Yes ☐ 2. No, ***please go to Q10***

9. If yes in Q8, who are they? (you may tick more than one)
   ☐ 1. Spouse ☐ 2. Children ☐ 3. Relatives
   ☐ 4. Brothers and sisters ☐ 5. Parents

10. Did you work off-farm **during the last 12 months**?
    ☐ 1. Yes ☐ 2. No, ***go to Q13***

11. What type of off-farm job did you engage in? *(check all that apply)*
    ☐ 1. Privately owned business (e.g. rice mill, dairy shop)
    ☐ 2. Wage labour
    ☐ 3. Agricultural labour
    ☐ 4. Special craftsman
    ☐ 5. Other (s) please specify ____

12. What is your net off-farm income **during the last 12 months**?
    ☐ 1. Less than 5,000 baht ☐ 2. Between 5,001 to 10,000 baht
    ☐ 3. Between 10,001 to 15,000 baht ☐ 4. Between 15,001 to 20,000 baht
    ☐ 5. More than 20,000 baht
    ☐ 6. Other (s) please specify ____

13. What is your annual household income?

☐ 1. Less than 10,000 baht	☐ 2. Between 10,001 to 30,000 baht
☐ 3. Between 30,001 to 50,000 baht	☐ 4. Between 50,001 to 70,000 baht
☐ 5. Between 70,001 to 90,000 baht	☐ 6. More than 90,000 baht

☐ 7. Other (s) please specify ____

Your participation in this survey is greatly appreciated. Thank you for your time and if you have further comments about risk analysis of smallholder farmers, please feel free to comment in the space provided below. Once again we assure you that your identity will remain ***STRICTLY CONFIDENTIAL.***

Appendix B

Correlations of sources of risk and risk management strategy components and socioeconomic variables

B.1 Pearson correlation coefficients of source of risk components 1 to 6 (AS1-6) and socioeconomic characteristics of all farmer group

	AGE	*GEN*	*EDU*	*EXP*	*OFFW*	*FSIZ*	*INCM*	*LOC*	*FINC*	*AHIN*	*HSIZ*
AS1	-0.054	-0.007	0.061^{**}	-0.068^{**}	0.077^{**}	-0.023	-0.017	-0.028	0.001	0.073^{**}	0.095^{***}
AS2	-0.102^{***}	-0.111^{***}	0.182^{***}	-0.118^{***}	0.231^{***}	0.036	0.031	0.201^{***}	-0.048	0.070^{**}	0.097^{***}
AS3	-0.080^{**}	-0.068^{**}	0.052	-0.034	0.065^{**}	0.019	0.149^{***}	0.172^{***}	0.108^{***}	0.064^{**}	0.025
AS4	-0.058	-0.033	0.070^{**}	-0.101^{***}	0.077^{**}	-0.006	0.012	0.099^{***}	0.176^{***}	0.050	0.030
AS5	-0.068^{**}	-0.025	0.094^{***}	-0.050	0.085^{***}	0.016	0.024	0.071^{**}	0.002	0.066^{**}	0.001
AS6	-0.035	0.012	0.002	0.021	0.049	-0.064^{**}	-0.023	0.033	0.035	0.001	-0.015
AGE	1	0.001	-0.205^{***}	0.313^{***}	-0.209^{***}	0.057	0.019	-0.067^{**}	0.023	0.010	-0.054
GEN		1	0.023	-0.005	0.042	0.100^{***}	0.076^{**}	-0.029	0.012	0.072^{**}	-0.063^{**}
EDU			1	-0.270^{***}	0.238^{***}	-0.005	0.026	0.133^{***}	-0.120^{***}	0.131^{***}	-0.070^{**}
EXP				1	-0.264^{***}	-0.041	-0.100^{***}	-0.320^{***}	-0.004	-0.012	0.028
OFFW					1	-0.103^{***}	0.050	0.233^{***}	-0.045	0.001	-0.006
FSIZ						1	0.556^{***}	0.337^{***}	0.103^{***}	0.416^{***}	0.079^{**}
INCM							1	0.563^{***}	0.082^{**}	0.472^{***}	0.084^{**}
LOC								1	0.013	0.305^{***}	0.023
FINC									1	0.001	0.005
AHIN										1	0.040
HSIZ											1

Correlation is significant at $^{*}P < 0.1$, $^{**}P < 0.05$ and $^{***}P < 0.01$

B.2 Pearson correlation coefficients of sources of risk components 1 to 6 (CS1-6) and socioeconomic characteristics of central region farmer group

	AGE	*GEN*	*EDU*	*EXP*	*OFFW*	*FSIZ*	*INCM*	*LOC*	*FINC*	*AHIN*	*HSIZ*
CS1	-0.109**	-0.155***	0.176***	-0.097**	0.217***	-0.134***	-0.216***	0.143***	-0.017	-0.095**	0.085**
CS2	-0.063	-0.106**	0.115**	0.031	0.095**	-0.085**	-0.021	-0.206***	-0.083**	0.157***	0.170***
CS3	-0.120***	-0.086**	0.129***	-0.003	0.102**	-0.001	-0.007	-0.190***	-0.110**	0.129***	0.081
CS4	-0.073	-0.040	0.105**	0.031	0.139***	-0.158***	-0.105**	-0.230***	0.009	0.146***	0.146***
CS5	-0.113**	-0.064	0.061	-0.071	0.161***	-0.153***	-0.118***	0.008	0.043	-0.060	-0.019
CS6	-0.104**	-0.154***	0.103**	-0.072	0.193***	-0.117***	0.045	-0.233***	0.060	-0.048	0.065
AGE	1	0.078	-0.247***	0.254***	-0.165***	0.088**	0.072	0.096**	0.043	-0.005	-0.066
GEN		1	-0.061	-0.012	0.008	0.108**	0.111**	0.056	0.038	0.035	-0.083**
EDU			1	-0.255***	0.257***	-0.122***	-0.064	-0.100**	-0.176***	0.085**	-0.054
EXP				1	-.182***	0.111**	0.128***	-0.007	0.008	0.094**	0.072
OFFW					1	-0.247***	-0.074	-0.048	-0.025	-0.052	0.015
FSIZ						1	0.543***	0.181***	0.207***	0.259***	0.047
INCM							1	-0.386***	0.112**	0.434***	0.083**
LOC								1	0.069	-0.353***	-0.095**
FINC									1	-0.045	0.003
AHIN										1	0.037
HSIZ											1

Correlation is significant at * $P < 0.1$, ** $P < 0.05$ and *** $P < 0.01$

B.3 Pearson correlation coefficients of sources of risk components 1 to 6 (NS1-6) and socioeconomic characteristics of north-east region farmer group

	AGE	*GEN*	*EDU*	*EXP*	*OFFW*	*FSIZ*	*INCM*	*LOC*	*FINC*	*AHIN*	*HSIZ*
NS1	-0.051	0.079	0.015	-0.181***	0.078	0.040	0.046	0.009	0.073	0.029	0.032
NS2	-0.029	-0.036	0.067	-0.054	0.100**	0.062	0.012	0.169***	0.027	-0.059	0.036
NS3	-0.047	-0.002	-0.029	0.090**	-0.087**	0.004	0.138***	-0.321***	0.143***	0.051	-0.009
NS4	-0.060	-0.048	0.058	-0.163***	0.033	0.020	-0.031	0.137***	0.283***	-0.075	-0.053
NS5	0.009	0.046	0.028	-0.058	0.038	-0.014	-0.063	-0.010	0.119***	-0.034	-0.087**
NS6	0.120***	0.021	-0.009	0.133***	-0.078	0.063	0.060	-0.003	0.011	0.108**	0.011
AGE	1	-0.099**	-0.126***	0.378***	-0.240***	0.083**	0.078	-0.057	0.002	0.073	-0.037
GEN		1	0.139***	-0.019	0.093**	0.125***	0.151***	-0.068	-0.013	0.133***	-0.042
EDU			1	-0.230***	0.166***	0.019	-0.062	0.073	-0.061	0.110**	-0.097**
EXP				1	-0.229***	0.042	0.069	-0.158***	-0.007	0.097**	0.004
OFFW					1	-0.156***	-0.209***	0.105**	-0.074	-0.097**	-0.038
FSIZ						1	0.512***	0.178***	0.015	0.422***	0.100**
INCM							1	-0.308***	0.064	0.416***	0.127***
LOC								1	-0.128***	-0.208***	-0.029
FINC									1	0.034	0.005
AHIN										1	0.031
HSIZ											1

Correlation is significant at * $P < 0.1$, ** $P < 0.05$ and *** $P < 0.01$

B.4 Pearson correlation coefficients of risk management components 1 to 4 (AR1-4) and socioeconomic characteristics of all farmer group

	AGE	*GEN*	*EDU*	*EXP*	*OFFW*	*FSIZ*	*INCM*	*LOC*	*FINC*	*AHIN*	*HSIZ*
AR1	-0.056	-0.008	0.155^{***}	-0.059^{**}	0.140^{***}	-0.165^{***}	-0.254^{***}	-0.235^{***}	-0.108^{***}	-0.106^{***}	0.032
AR2	-0.035	-0.057	0.099^{***}	-0.130^{***}	0.124^{***}	-0.077^{**}	-0.256^{***}	0.130^{***}	-0.039	-0.218^{***}	-0.021
AR3	-0.137^{***}	-0.038	0.266^{***}	-0.200^{***}	0.475^{***}	-0.049	-0.007	0.147^{***}	-0.124^{***}	0.027	0.023
AR4	-0.054	-0.024	-0.101^{***}	-0.075^{**}	0.107^{***}	-0.113^{***}	-0.132^{***}	-0.092^{***}	-0.042	0.006	-0.018
AGE	1	0.001	-0.205^{***}	0.313^{***}	-0.209^{***}	0.057	0.019	-0.067^{**}	0.023	0.010	-0.054
GEN		1	0.023	-0.005	0.042	0.100^{***}	0.076^{**}	-0.029	0.012	0.072^{**}	-0.063^{**}
EDU			1	-0.270^{***}	0.238^{***}	-0.005	0.026	0.133^{***}	-0.120^{***}	0.131^{***}	-0.070^{**}
EXP				1	-0.264^{***}	-0.041	-0.100^{***}	-0.320^{***}	-0.004	-0.012	0.028
OFFW					1	-0.103^{***}	0.050	0.233^{***}	-0.045	0.001	-0.006
FSIZ						1	0.556^{***}	0.337^{***}	0.103^{***}	0.416^{***}	0.079^{**}
INCM							1	0.563^{***}	0.082^{**}	0.472^{***}	0.084^{***}
LOC								1	0.013	0.305^{***}	0.023
FINC									1	0.001	0.005
AHIN										1	0.040
HSIZ											1

Correlation is significant at $^{*}P < 0.1$, $^{**}P < 0.05$ and $^{***}P < 0.01$

B.5 Pearson correlation coefficients of risk management components 1 to 4 (CR1-4) and socioeconomic characteristics of central region farmer group

	AGE	*GEN*	*EDU*	*EXP*	*OFFW*	*FSIZ*	*INCM*	*LOC*	*FINC*	*AHIN*	*HSIZ*
CR1	-0.141***	-0.092**	0.183***	-0.082	0.242***	-0.166***	-0.197***	0.003	-0.085**	-0.111**	0.136***
CR2	-0.079	-0.104**	0.136***	-0.147***	0.201***	-0.185***	-0.334***	0.33***9	-0.067	-0.326***	-0.012
CR3	-0.139***	-0.123***	0.310***	-0.092**	0.531***	-0.216***	-0.141***	-0.017	-0.123***	-0.089**	0.076
CR4	-0.128***	-0.075	0.134***	-0.099**	0.159***	-0.151***	-0.124***	0.067	-0.099**	0.018	0.012
AGE	1	0.078	0.247***	0.254***	-0.165***	0.088**	0.072	0.096**	0.043	-0.005	-0.066
GEN		1	-0.061	-0.012	0.008	0.108**	0.111**	0.056	0.038	0.035	-0.083**
EDU			1	-0.255***	0.257***	-0.122***	-0.064	-0.100**	-0.176***	0.085**	-0.054
EXP				1	-0.182***	0.111**	0.128***	-0.007	0.008	0.094**	0.072
OFFW					1	-0.247***	-0.074	-0.048	-0.025	-0.052	0.015
FSIZ						1	0.543***	0.181***	0.207***	0.259***	0.047
INCM							1	-0.386***	0.112**	0.434***	0.083**
LOC								1	0.069	-0.353***	-0.095**
FINC									1	-0.045	0.003
AHIN										1	0.037
HSIZ											1

Correlation is significant at * $P < 0.1$, ** $P < 0.05$ and *** $P < 0.01$

B.6 Pearson correlation coefficients of risk management components 1 to 3 (NR1-3) and socioeconomic characteristics of north-east region farmer group

	AGE	*GEN*	*EDU*	*EXP*	*OFFW*	*FSIZ*	*INCM*	*LOC*	*FINC*	*AHIN*	*HSIZ*
NR1	-0.013	0.098**	0.146***	-0.205***	0.087**	0.061	0.090**	0.041	-0.035	0.100**	-0.045
NR2	-0.111**	0.036	0.193***	-0.281***	0.323***	0.035	-0.041	0.183***	-0.126***	0.036	-0.011
NR3	0.016	0.005	0.025	-0.216***	0.099**	0.076	0.031	0.209***	0.005	-0.018	0.023
AGE	1	-0.099**	-0.126***	0.378***	-0.240***	0.083**	0.078	-0.057	0.002	0.073	-0.037
GEN		1	0.139***	-0.019	0.093**	0.125***	0.151***	-0.068	-0.013	0.133***	-0.042
EDU			1	-0.230***	0.166***	0.019	-0.062	0.073	-0.061	0.110**	-0.097**
EXP				1	-0.229***	0.042	0.069	-0.158***	-0.007	0.097**	0.004
OFFW					1	-0.156***	-0.209***	0.105**	-0.074	-0.097**	-0.038
FSIZ						1	0.512***	0.178***	0.015	0.422***	0.100**
INCM							1	-0.308***	0.064	0.416***	0.127***
LOC								1	-0.128***	-0.208***	-0.029
FINC									1	0.034	0.005
AHIN										1	0.031
HSIZ											1

Correlation is significant at $^{*}P < 0.1$, $^{**}P < 0.05$ and $^{***}P < 0.01$

Appendix C

Absolute risk aversion coefficients

C.1 Summary of parameter coefficients estimated by four different utility functions using the non-linear least square method for central region farmers

Parameter(s) and R^2 of each functional form	*Mean estimated* [a]	*High estimated* [a]	*Low estimated* [a]	*Percentage by which parameters and R^2 are significant* [c]
Cubic function				
a	0.0012218	0.1050300	-0.0833220	1
b	0.0000174	0.0000569	-0.0000197	64
c	-1.65E-11	1.16E-09	-1.07E-09	56
d	-5.81E-16	6.04E-15	-9.56E-15	55
R^2 [b]	0.985	0.999	0.928	100
Negative exponential function				
c	0.0000300	0.0001330	0.0000144	100
R^2 [b]	0.926	0.995	0.657	100
Power function [d]				
α	-0.051454	0.0214550	-0.100735	0
β	0.0028355	0.0263880	3.85E-08	2
γ	0.6908190	1.4892590	0.3254880	100
R^2 [b]	0.942	0.999	0.750	100
Expo-power function [e]				
γ	1.0062349	1.0589530	0.9598710	100
β	0.0000573	0.0029390	1.84E-09	1
α	1.4556039	1.9012240	0.6176960	100
R^2 [b]	0.979	0.999	0.844	100

[a] The 207 regression equations were estimated for each utility functional form.

[b] R^2 is the coefficient to assess the goodness of curve fit when each utility functional form was employed to fit with the individual sequence of data points from the ELCE elicitation method.

[c] The statistically significance at the 10 per cent level was employed on the t-statistic for the parameters and F-statistic for R^2.

[d] 25 equations had violated parameter restrictions for the power utility function.

[e] 85 equations had violated parameters restrictions for the expo-power utility function.

Source: Field survey, 2009

C.2 Summary of parameter coefficients estimated by four different utility functions using the non-linear least square method for north-east region farmers

Parameter(s) and R^2 of each functional form	*Mean estimated*[a]	*High estimated*[a]	*Low Estimated*[a]	*Percentage by which parameters and R^2 are significant*[c]
Cubic function				
a	0.01541351	0.1279060	-0.1124360	10
b	0.00001992	0.0009330	-0.0000184	63
c	-1.13E-09	9.33E-10	-2.45E-07	46
d	1.02E-14	2.35E-12	-8.08E-15	46
R^2 [b]	0.986	0.999	0.929	100
Negative exponential function				
c	0.0000345	0.0012450	0.0000109	100
R^2 [b]	0.930	0.996	0.544	100
Power function [d]				
α	-0.0345938	0.0570960	-0.2307760	0
β	0.0056593	0.2942850	2.07E-08	3
γ	0.7431495	1.5479450	0.1298320	99
R^2 [b]	0.965	0.999	0.705	100
Expo-power function [e]				
γ	1.0204643	1.0933600	0.9484040	100
β	0.0001332	0.0101570	7.93E-10	4
α	1.4180671	1.9258560	0.4877080	99
R^2 [b]	0.978	0.999	0.733	100

[a] The 228 regression equations were estimated for each utility functional form.

[b] R^2 is the coefficient to assess the goodness of curve fit when each utility functional form was employed to fit with the individual sequence of data points from the ELCE elicitation method.

[c] The statistically significance at the 10 per cent level was employed on the t-statistic for the parameters and F-statistic for R^2.

[d] 40 equations had violated parameter restrictions for the power utility function.

[e] 54 equations had violated parameters restrictions for the expo-power utility function.

Source: Field survey, 2009

C.3 The absolute risk aversion coefficients estimated by four different utility functions for central region farmers (n=207)

Respondent Number	*Absolute risk aversion coefficients*			
	Cubic function	*Negative exponential function*	*Power function*	*Expo-power function*
401	0.0000051	0.0000187	0.0000012	0.0000214
402	0.0001804	0.0000239	0.0000061	0.0000232
403	0.0000046	0.0000185	0.0000013	0.0000229
404	0.0010622	0.0000221	0.0000055	0.0000228
405	0.0000248	0.0000243	0.0000062	0.0000299
406	-0.0000153	0.0000220	0.0000050	0.0000172
407	-0.0000245	0.0000220	0.0000046	0.0000171
412	-0.0000305	0.0000249	0.0000069	0.0000229
413	-0.0000172	0.0000237	0.0000065	0.0000204
415	-0.0000298	0.0000227	0.0000057	0.0000193
416	-0.0000435	0.0000228	0.0000055	0.0000209
417	-0.0000424	0.0000231	0.0000063	0.0000214
418	0.0002422	0.0000220	0.0000046	0.0000187
421	0.0000411	0.0000242	0.0000059	0.0000241
422	-0.0000985	0.0000245	0.0000063	0.0000246
425	-0.0000301	0.0000236	0.0000063	0.0000209
427	0.0002378	0.0000227	0.0000054	0.0000219
429	-0.0000374	0.0000212	0.0000044	0.0000180
435	-0.0000296	0.0000230	0.0000059	0.0000220
436	-0.0000748	0.0000220	0.0000053	0.0000211
438	-0.0000545	0.0000227	0.0000055	0.0000209
442	-0.0002629	0.0000223	0.0000050	0.0000193
444	-0.0000210	0.0000236	0.0000061	0.0000214
447	-0.0000526	0.0000226	0.0000059	0.0000199
449	0.0000242	0.0000231	0.0000054	0.0000210
452	0.0000704	0.0000354	0.0000098	0.0000987
454	0.0000727	0.0000237	0.0000057	0.0000254
455	-0.0000097	0.0000610	0.0000128	0.0000958
456	-0.0000166	0.0000320	0.0000090	0.0000398
459	-0.0000141	0.0000374	0.0000106	0.0000346
460	0.0000513	0.0000282	0.0000080	0.0000515
462	0.0000077	0.0000228	0.0000053	0.0000429
463	0.0000068	0.0000239	0.0000055	0.0000267
466	-0.0000732	0.0000369	0.0000102	0.0000471
467	-0.0000578	0.0000332	0.0000099	0.0000365
468	-0.0001118	0.0000362	0.0000100	0.0000744
471	-0.0000312	0.0000319	0.0000092	0.0000984
472	-0.0002044	0.0000323	0.0000090	0.0000691
473	-0.0000170	0.0000358	0.0000104	0.0000511
474	-0.0000163	0.0000357	0.0000105	0.0000513
475	-0.0000115	0.0000529	0.0000122	0.0000428
490	-0.0000115	0.0000529	0.0000122	0.0000430
495	-0.0004612	0.0000234	0.0000057	0.0000223
496	-0.0000257	0.0000292	0.0000088	0.0000846
497	-0.0000355	0.0000305	0.0000087	0.0000340
498	-0.0000407	0.0000378	0.0000101	0.0000720
499	-0.0000120	0.0000415	0.0000109	0.0000399
500	-0.0000072	0.0000498	0.0000116	0.0000382
501	-0.0000117	0.0000477	0.0000119	0.0000364

C.3 The absolute risk aversion coefficients estimated by four different utility functions for central region farmers (n=207) (cont.)

Respondent Number	*Absolute risk aversion coefficients*			
	Cubic function	*Negative exponential function*	*Power function*	*Expo-power function*
502	-0.0000072	0.0000535	0.0000122	0.0000412
503	-0.0000182	0.0000306	0.0000091	0.0000310
505	-0.0000107	0.0000481	0.0000121	0.0000370
507	-0.0000115	0.0000416	0.0000110	0.0000423
510	-0.0000270	0.0000323	0.0000094	0.0000309
512	0.0000080	0.0000214	0.0000040	0.0000362
513	-0.0000082	0.0000471	0.0000120	0.0000307
514	-0.0000110	0.0000479	0.0000119	0.0000417
515	0.0001002	0.0000351	0.0000097	0.0000621
517	-0.0000095	0.0000423	0.0000112	0.0000376
519	-0.0000069	0.0001330	0.0000135	0.0000367
520	0.0000168	0.0000261	0.0000069	0.0000344
521	-0.0000157	0.0000477	0.0000115	0.0000712
525	-0.0000074	0.0000503	0.0000119	0.0000457
526	-0.0000440	0.0000331	0.0000092	0.0000486
527	-0.0000086	0.0000446	0.0000113	0.0000355
528	-0.0000109	0.0000438	0.0000112	0.0000392
529	-0.0000109	0.0000356	0.0000101	0.0000360
530	-0.0000096	0.0000542	0.0000120	0.0000563
532	-0.0000101	0.0000498	0.0000118	0.0000446
533	-0.0000139	0.0000390	0.0000104	0.0000430
535	-0.0000170	0.0000489	0.0000115	0.0000843
536	-0.0000138	0.0000400	0.0000105	0.0000447
537	-0.0000125	0.0000477	0.0000114	0.0000666
538	-0.0000212	0.0000375	0.0000102	0.0000475
540	-0.0000285	0.0000408	0.0000109	0.0000493
541	-0.0000106	0.0000482	0.0000117	0.0000418
542	-0.0000129	0.0000473	0.0000115	0.0001571
543	-0.0000115	0.0000454	0.0000112	0.0000438
545	-0.0000111	0.0000426	0.0000110	0.0000402
546	-0.0000164	0.0000312	0.0000088	0.0000382
547	-0.0000110	0.0000405	0.0000108	0.0000357
548	-0.0000121	0.0000466	0.0000114	0.0000511
550	0.0000089	0.0000314	0.0000099	0.0000479
555	-0.0000234	0.0000379	0.0000104	0.0000540
556	-0.0000771	0.0000348	0.0000099	0.0000434
557	-0.0000152	0.0000391	0.0000107	0.0000590
558	-0.0000292	0.0000364	0.0000102	0.0000468
564	0.0000108	0.0000289	0.0000086	0.0000408
565	-0.0000083	0.0000541	0.0000122	0.0000329
566	0.0000051	0.0000185	0.0000009	0.0000225
568	-0.0000386	0.0000273	0.0000074	0.0000395
572	-0.0000087	0.0001030	0.0000125	0.0000361
575	-0.0000112	0.0000411	0.0000110	0.0000363
577	-0.0000006	0.0000179	-0.0000010	0.0000135
578	-0.0000084	0.0000529	0.0000120	0.0000326
579	-0.0000127	0.0000443	0.0000116	0.0000355
580	0.0000146	0.0000273	0.0000073	0.0000286

C.3 The absolute risk aversion coefficients estimated by four different utility functions for central region farmers (n=207) (cont.)

Respondent Number	*Absolute risk aversion coefficients*			
	Cubic function	*Negative exponential function*	*Power function*	*Expo-power function*
581	0.0000074	0.0000228	0.0000047	0.0000258
583	0.0000128	0.0000253	0.0000066	0.0000536
584	0.0000191	0.0000243	0.0000059	0.0000399
585	0.0000235	0.0000247	0.0000062	0.0000317
586	0.0000109	0.0000222	0.0000045	0.0000320
587	0.0000097	0.0000207	0.0000036	0.0000343
588	0.0000032	0.0000195	0.0000018	0.0000200
589	0.0000082	0.0000207	0.0000036	0.0000337
593	0.0000087	0.0000228	0.0000052	0.0000399
595	0.0000112	0.0000254	0.0000068	0.0000607
601	-0.0000029	0.0000175	-0.0000018	0.0000112
602	-0.0000035	0.0000183	-0.0000018	0.0000111
603	0.0000012	0.0000196	0.0000004	0.0000147
604	-0.0000736	0.0000314	0.0000095	0.0000295
605	0.0000019	0.0000199	0.0000010	0.0000156
606	-0.0000005	0.0000187	-0.0000010	0.0000120
610	0.0000011	0.0000192	-0.0000002	0.0000142
611	0.0000019	0.0000199	0.0000010	0.0000156
612	-0.0000005	0.0000187	-0.0000010	0.0000120
614	-0.0000004	0.0000188	-0.0000012	0.0000129
615	0.0000077	0.0000216	0.0000039	0.0000189
616	-0.0003118	0.0000171	-0.0000055	0.0000086
617	0.0000020	0.0000201	0.0000012	0.0000159
618	0.0000190	0.0000228	0.0000053	0.0000260
619	0.0000023	0.0000195	0.0000006	0.0000150
620	-0.0000149	0.0000331	0.0000106	0.0000289
621	0.0000704	0.0000354	0.0000098	0.0000987
622	0.0000018	0.0000204	0.0000014	0.0000154
623	0.0000056	0.0000210	0.0000035	0.0000266
624	0.0000544	0.0000264	0.0000073	0.0000425
625	0.0000099	0.0000313	0.0000090	0.0000629
635	0.0000099	0.0000313	0.0000090	0.0000629
636	0.0000209	0.0000326	0.0000093	0.0000820
637	0.0000169	0.0000230	0.0000054	0.0000329
638	0.0000232	0.0000476	0.0000118	0.0001199
639	-0.0000033	0.0000144	-0.0000073	0.0000085
640	0.0000160	0.0000299	0.0000085	0.0000540
641	0.0000100	0.0000311	0.0000089	0.0000635
642	0.0000011	0.0000177	0.0000001	0.0000191
643	0.0000133	0.0000274	0.0000076	0.0000412
654	0.0000243	0.0000472	0.0000116	0.0001216
656	0.0000168	0.0000298	0.0000085	0.0000907
659	0.0000076	0.0000269	0.0000077	0.0000641
660	0.0000096	0.0000318	0.0000092	0.0000640
664	0.0000099	0.0000313	0.0000090	0.0000629
665	0.0000704	0.0000354	0.0000098	0.0000987
668	0.0000051	0.0000228	0.0000053	0.0000358
669	0.0000100	0.0000306	0.0000088	0.0000670

C.3 The absolute risk aversion coefficients estimated by four different utility functions for central region farmers (n=207) (cont.)

Respondent Number	*Absolute risk aversion coefficients*			
	Cubic function	*Negative exponential function*	*Power function*	*Expo-power function*
671	0.0000147	0.0000406	0.0000108	0.0001457
672	0.0000216	0.0000241	0.0000056	0.0000233
675	0.0000006	0.0000180	-0.0000010	0.0000151
677	0.0000333	0.0000436	0.0000113	0.0000879
678	0.0000099	0.0000313	0.0000090	0.0000629
679	0.0000127	0.0000308	0.0000088	0.0000634
681	0.0000056	0.0000225	0.0000050	0.0000335
682	0.0000173	0.0000281	0.0000078	0.0000461
684	0.0005091	0.0000413	0.0000109	0.0000715
685	0.0000027	0.0000217	0.0000035	0.0000192
687	0.0000243	0.0000472	0.0000116	0.0001216
690	-0.0000377	0.0000146	-0.0000098	0.0000046
692	0.0000041	0.0000231	0.0000041	0.0000169
694	0.0000127	0.0000308	0.0000088	0.0000634
698	0.0000021	0.0000193	0.0000004	0.0000151
701	-0.0000183	0.0000256	0.0000077	0.0000243
702	0.0000022	0.0000180	0.0000002	0.0000127
703	0.0000090	0.0000225	0.0000044	0.0000218
704	-0.0000038	0.0000159	-0.0000048	0.0000086
707	0.0000165	0.0000239	0.0000055	0.0000218
710	-0.0000540	0.0000314	0.0000094	0.0000519
712	0.0000891	0.0000257	0.0000078	0.0000268
713	0.0000025	0.0000189	-0.0000002	0.0000154
714	-0.0001556	0.0000225	0.0000050	0.0000207
719	-0.0000945	0.0000255	0.0000070	0.0000245
720	-0.0000125	0.0000180	-0.0000039	0.0000097
721	-0.0001133	0.0000279	0.0000082	0.0000288
722	0.0000136	0.0000226	0.0000047	0.0000209
724	-0.0004151	0.0000281	0.0000082	0.0000339
725	0.0000052	0.0000203	0.0000023	0.0000147
728	0.0000018	0.0000184	0.0000001	0.0000128
729	-0.0000019	0.0000169	-0.0000025	0.0000098
730	0.0000120	0.0000229	0.0000052	0.0000279
731	0.0000018	0.0000184	-0.0000001	0.0000142
732	0.0000004	0.0000184	0.0000001	0.0000135
734	0.0000191	0.0000270	0.0000075	0.0000293
735	0.0000091	0.0000202	0.0000026	0.0000167
737	-0.0000015	0.0000188	0.0000001	0.0000103
739	0.0000123	0.0000218	0.0000038	0.0000161
746	-0.0000377	0.0000146	-0.0000098	0.0000046
750	0.0000041	0.0000231	0.0000042	0.0000169
758	0.0000056	0.0000210	0.0000035	0.0000266
761	0.0000019	0.0000199	0.0000010	0.0000156
762	-0.0000005	0.0000187	-0.0000010	0.0000120
765	0.0000007	0.0000189	-0.0000005	0.0000136
767	0.0000008	0.0000176	-0.0000012	0.0000157
770	0.0000023	0.0000195	0.0000006	0.0000150
771	0.0000151	0.0000370	0.0000105	0.0000552

C.3 The absolute risk aversion coefficients estimated by four different utility functions for central region farmers (n=207) (cont.)

Respondent Number	*Absolute risk aversion coefficients*			
	Cubic function	*Negative exponential function*	*Power function*	*Expo-power function*
772	0.0000173	0.0000281	0.0000078	0.0000461
773	0.0000333	0.0000436	0.0000113	0.0000879
774	-0.0000144	0.0000152	-0.0000096	0.0000067
777	-0.0000377	0.0000146	-0.0000098	0.0000046
779	0.0000368	0.0000331	0.0000099	0.0000350
781	0.0000022	0.0000186	0.0000004	0.0000173
782	0.0000100	0.0000221	0.0000042	0.0000232
784	0.0000135	0.0000263	0.0000070	0.0000238
785	0.0000050	0.0000196	0.0000018	0.0000205
789	-0.0000044	0.0000168	-0.0000053	0.0000121
794	0.0000099	0.0000233	0.0000049	0.0000221
795	0.0000024	0.0000197	0.0000011	0.0000158
797	0.0000012	0.0000192	0.0000008	0.0000172
799	-0.0000200	0.0000418	0.0000116	0.0000368

Source: Field survey, 2009

C.4 The absolute risk aversion coefficients estimated by four different utility functions for northeast region farmers (n=228)

Respondent Number	*Absolute risk aversion coefficients*			
	Cubic function	*Negative exponential function*	*Power function*	*Expo-power function*
1	-0.0001548	0.0000348	0.0000102	0.0000320
2	-0.0000074	0.0001700	0.0000142	0.0000296
4	0.0000088	0.0000238	0.0000055	0.0000275
6	0.0000094	0.0000220	0.0000044	0.0000277
7	0.0000177	0.0000201	0.0000035	0.0000279
10	0.0000081	0.0000197	0.0000030	0.0000187
12	-0.0000021	0.0000185	-0.0000011	0.0000117
14	0.0000127	0.0000226	0.0000049	0.0000278
15	0.0000152	0.0000223	0.0000046	0.0000220
16	0.0000854	0.0000301	0.0000088	0.0000305
19	0.0000256	0.0000240	0.0000062	0.0000289
20	0.0000018	0.0000186	-0.0000010	0.0000144
23	-0.0000009	0.0000193	-0.0000006	0.0000122
29	-0.0000110	0.0000157	-0.0000071	0.0000072
31	-0.0000146	0.0000239	0.0000068	0.0000210
36	0.0000033	0.0000193	0.0000010	0.0000172
38	-0.0001251	0.0000296	0.0000155	0.0000357
45	0.0005569	0.0000109	-0.0000110	-0.0000005
46	0.0000125	0.0000391	0.0000116	0.0000526
49	0.0000187	0.0000218	0.0000040	0.0000142
50	-0.0000272	0.0000307	0.0000097	0.0000273
51	-0.0000800	0.0000236	0.0000066	0.0000157
53	-0.0000009	0.0000209	0.0000032	0.0000081

C.4 The absolute risk aversion coefficients estimated by four different utility functions for north-east region farmers (n=228) (cont.)

Respondent Number	*Absolute risk aversion coefficients*			
	Cubic function	*Negative exponential function*	*Power function*	*Expo-power function*
54	-0.0000119	0.0000441	0.0000112	0.0000409
55	-0.0000092	0.0000214	0.0000051	0.0000193
56	0.0000910	0.0000228	0.0000052	0.0000168
57	0.0000205	0.0000250	0.0000064	0.0000272
62	-0.0000071	0.0000210	0.0000027	0.0000105
68	-0.0001343	0.0000289	0.0000088	0.0000282
69	0.0001213	0.0000267	0.0000076	0.0000259
70	-0.0000207	0.0000274	0.0000081	0.0000275
71	0.0000009	0.0000181	-0.0000001	0.0000135
72	0.0000723	0.0000276	0.0000076	0.0000399
75	0.0000042	0.0000188	0.0000012	0.0000160
76	-0.0000102	0.0000295	0.0000098	0.0000260
78	-0.0000043	0.0000162	-0.0000048	0.0000074
79	0.0000010	0.0000181	-0.0000005	0.0000163
80	0.0000087	0.0000198	0.0000020	0.0000183
82	-0.0000124	0.0000233	0.0000063	0.0000240
83	0.0000126	0.0000217	0.0000044	0.0000304
84	-0.0000507	0.0000295	0.0000081	0.0000429
85	-0.0000035	0.0000965	0.0000141	0.0000470
87	-0.0000556	0.0000337	0.0000107	0.0000278
90	-0.0000005	0.0000177	-0.0000024	0.0000119
92	0.0000133	0.0000206	0.0000044	0.0000244
94	0.0001711	0.0000412	-0.0000096	0.0000039
95	-0.0000151	0.0000412	0.0000110	0.0000408
96	-0.0000018	0.0000150	-0.0000059	0.0000098
102	-0.0000097	0.0000231	0.0000069	0.0000166
103	-0.0000156	0.0000320	0.0000099	0.0000324
105	-0.0005440	0.0000292	0.0000086	0.0000285
106	0.0000001	0.0000190	-0.0000006	0.0000124
108	-0.0000156	0.0000337	0.0000107	0.0000281
109	-0.0000063	0.0000193	0.0000016	0.0000119
110	0.0000179	0.0000172	-0.0000020	0.0000112
111	-0.0000070	0.0000269	0.0000099	0.0000227
112	0.0000171	0.0000208	0.0000034	0.0000139
114	0.0000100	0.0000203	0.0000025	0.0000157
115	0.0000284	0.0000237	0.0000054	0.0000214
116	0.0000009	0.0000188	-0.0000004	0.0000137
117	-0.0000301	0.0000306	0.0000095	0.0000263
119	0.0000032	0.0000183	0.0000002	0.0000133
120	0.0000630	0.0000270	0.0000078	0.0000219
121	0.0000124	0.0000200	0.0000033	0.0000251
122	0.0000756	0.0000269	0.0000079	0.0000217
123	-0.0000105	0.0000326	0.0000097	0.0000339
124	0.0000498	0.0000989	0.0000153	0.0002562
125	-0.0000072	0.0000220	0.0000065	0.0000236
126	-0.0000270	0.0000275	0.0000091	0.0000230
128	-0.0000068	0.0000988	0.0000141	0.0000506
129	-0.0000001	0.0000172	-0.0000016	0.0000122

C.4 The absolute risk aversion coefficients estimated by four different utility functions for north-east region farmers (n=228) (cont.)

Respondent Number	*Absolute risk aversion coefficients*			
	Cubic function	*Negative exponential function*	*Power function*	*Expo-power function*
130	-0.0000078	0.0000265	0.0000093	0.0000231
132	0.0000039	0.0000177	0.0000011	0.0000163
133	0.0000741	0.0000250	0.0000066	0.0000261
134	-0.0000169	0.0000235	0.0000062	0.0000201
135	-0.0000115	0.0000140	-0.0000093	0.0000052
136	0.0000041	0.0000191	0.0000021	0.0000141
138	0.0000095	0.0000267	0.0000071	0.0000274
141	0.0002170	0.0000263	0.0000074	0.0000210
142	-0.0000392	0.0000294	0.0000092	0.0000263
144	0.0000448	0.0000237	0.0000057	0.0000214
145	0.0000448	0.0000238	0.0000058	0.0000232
146	-0.0000079	0.0000211	0.0000045	0.0000185
150	-0.0000097	0.0000617	0.0000136	0.0000316
152	-0.0000142	0.0000228	0.0000059	0.0000241
153	0.0000117	0.0000195	0.0000032	0.0000183
154	-0.0000466	0.0000282	0.0000087	0.0000343
155	0.0012670	0.0000260	0.0000071	0.0000256
156	0.0000041	0.0000196	0.0000015	0.0000146
158	0.0000132	0.0000370	0.0000108	0.0000512
160	0.0000131	0.0000196	0.0000016	0.0000137
161	-0.0000014	0.0000192	-0.0000014	0.0000107
165	-0.0000071	0.0000247	0.0000081	0.0000217
166	0.0000173	0.0000256	0.0000066	0.0000402
169	-0.0000410	0.0000129	-0.0000098	0.0000029
170	-0.0000133	0.0000205	0.0000043	0.0000199
171	-0.0000027	0.0000922	0.0000144	0.0000755
172	0.0000252	0.0000231	0.0000053	0.0000243
175	0.0000039	0.0000189	0.0000013	0.0000174
176	0.0000055	0.0000197	0.0000016	0.0000148
179	-0.0000091	0.0000300	0.0000101	0.0000258
180	-0.0000094	0.0000251	0.0000081	0.0000215
182	0.0000017	0.0000184	-0.0000003	0.0000141
183	-0.0000052	0.0000160	-0.0000042	0.0000108
184	-0.0000041	0.0000150	-0.0000067	0.0000093
186	0.0000016	0.0000197	0.0000003	0.0000135
189	0.0000026	0.0000181	-0.0000001	0.0000150
190	-0.0000012	0.0000167	-0.0000030	0.0000140
193	-0.0000461	0.0000297	0.0000090	0.0000305
196	-0.0000179	0.0000233	0.0000061	0.0000227
201	0.0000583	0.0000170	-0.0000062	0.0000091
202	0.0000011	0.0000188	0.0000002	0.0000142
203	-0.0000282	0.0000137	-0.0000101	0.0000041
204	-0.0000238	0.0000142	-0.0000096	0.0000047
205	-0.0000076	0.0000449	0.0000112	0.0000404
206	-0.0000101	0.0000148	-0.0000074	0.0000073
207	0.0000026	0.0000170	-0.0000007	0.0000140
210	-0.0003442	0.0000239	0.0000071	0.0000276
211	0.0000090	0.0000207	0.0000037	0.0000325

C.4 The absolute risk aversion coefficients estimated by four different utility functions for north-east region farmers (n=228) (cont.)

Respondent Number	*Absolute risk aversion coefficients*			
	Cubic function	*Negative exponential function*	*Power function*	*Expo-power function*
212	-0.0000437	0.0000247	0.0000075	0.0000326
213	-0.0000028	0.0000193	-0.0000031	0.0000101
214	0.0000064	0.0000182	0.0000012	0.0000210
215	0.0000027	0.0000178	0.0000006	0.0000214
216	0.0000154	0.0000233	0.0000053	0.0000298
217	-0.0000190	0.0000182	-0.0000034	0.0000101
218	0.0000062	0.0000194	0.0000021	0.0000268
219	0.0000548	0.0000259	0.0000072	0.0000315
222	-0.0000121	0.0000491	0.0000134	0.0000283
223	-0.0000091	0.0000686	0.0000141	0.0000369
224	0.0000044	0.0000193	0.0000013	0.0000185
225	-0.0000125	0.0000508	0.0000125	0.0000339
227	0.0000764	0.0000226	0.0000050	0.0000224
228	0.0000012	0.0000164	-0.0000023	0.0000157
230	0.0000000	0.0000177	-0.0000012	0.0000137
231	0.0000077	0.0000179	0.0000015	0.0000191
232	0.0000202	0.0000251	0.0000066	0.0000501
237	0.0000218	0.0000260	0.0000068	0.0000315
238	-0.0000745	0.0000298	0.0000085	0.0001052
240	0.0000136	0.0000241	0.0000058	0.0000305
241	0.0000115	0.0000222	0.0000042	0.0000209
243	0.0000133	0.0000202	0.0000042	0.0000254
244	0.0000159	0.0000227	0.0000052	0.0000233
245	0.0000046	0.0000202	0.0000018	0.0000170
246	0.0000122	0.0012450	0.0000174	0.0030196
247	-0.0000130	0.0000451	0.0000113	0.0000454
248	0.0000010	0.0000186	-0.0000005	0.0000138
249	0.0000023	0.0000192	0.0000009	0.0000163
250	0.0000137	0.0000233	0.0000055	0.0000375
251	-0.0000224	0.0000418	0.0000113	0.0000420
252	-0.0000090	0.0000455	0.0000119	0.0000313
254	0.0000382	0.0000335	0.0000101	0.0000337
255	0.0000121	0.0000235	0.0000058	0.0000416
256	0.0000077	0.0000209	0.0000025	0.0000141
257	0.0000547	0.0000253	0.0000072	0.0000258
259	-0.0000056	0.0000147	-0.0000072	0.0000065
260	0.0004478	0.0000253	0.0000070	0.0000208
262	0.0000044	0.0000205	0.0000014	0.0000185
263	0.0000018	0.0000186	-0.0000001	0.0000144
264	-0.0000001	0.0001420	0.0000149	0.0000701
267	-0.0000075	0.0000908	0.0000146	0.0000902
268	0.0000818	0.0000431	0.0000118	0.0000481
269	-0.0033131	0.0000233	0.0000055	0.0000185
270	-0.0000083	0.0000189	0.0000006	0.0000105
274	0.0000231	0.0000247	0.0000063	0.0000302
275	0.0000253	0.0000247	0.0000065	0.0000257
276	0.0000024	0.0000201	0.0000009	0.0000115
277	0.0000592	0.0000250	0.0000070	0.0000162

C.4 The absolute risk aversion coefficients estimated by four different utility functions for north-east region farmers (n=228) (cont.)

Respondent Number	*Absolute risk aversion coefficients*			
	Cubic function	*Negative exponential function*	*Power function*	*Expo-power function*
278	0.0000087	0.0000219	0.0000042	0.0000213
279	0.0000748	0.0000311	0.0000097	0.0000261
280	-0.0000334	0.0000328	0.0000106	0.0000270
281	0.0000143	0.0000225	0.0000049	0.0000187
282	-0.0000316	0.0000163	-0.0000069	0.0000090
283	0.0000103	0.0000220	0.0000037	0.0000175
286	0.0000224	0.0000247	0.0000064	0.0000253
287	-0.0000097	0.0000298	0.0000099	0.0000262
288	0.0000110	0.0000211	0.0000033	0.0000186
289	-0.0000456	0.0000223	0.0000042	0.0000145
290	0.0000010	0.0000195	-0.0000004	0.0000080
294	-0.0000006	0.0001420	0.0000148	0.0000623
297	-0.0000150	0.0000460	0.0000123	0.0000330
299	0.0000082	0.0000248	0.0000057	0.0000225
300	-0.0000012	0.0000197	-0.0000014	0.0000112
301	0.0000888	0.0000187	-0.0000019	0.0000101
302	0.0000034	0.0000201	0.0000017	0.0000167
303	0.0000006	0.0000204	-0.0000004	0.0000114
304	0.0000116	0.0000223	0.0000043	0.0000227
305	-0.0000066	0.0000244	0.0000077	0.0000223
306	0.0000250	0.0000229	0.0000058	0.0000273
307	-0.0000159	0.0000240	0.0000065	0.0000201
308	0.0000100	0.0000222	0.0000030	0.0000154
314	0.0000322	0.0000237	0.0000058	0.0000208
316	0.0002257	0.0000241	0.0000059	0.0000208
317	0.0000304	0.0000272	0.0000074	0.0000369
318	-0.0000570	0.0000404	0.0000116	0.0000369
319	-0.0000180	0.0000331	0.0000106	0.0000266
323	0.0000304	0.0000275	0.0000075	0.0000363
327	0.0000427	0.0000245	0.0000064	0.0000230
331	-0.0000024	0.0000844	0.0000138	0.0001329
332	0.0000306	0.0000260	0.0000077	0.0000186
333	0.0001381	0.0000205	0.0000017	0.0000115
334	0.0000260	0.0000290	0.0000090	0.0000241
338	-0.0000428	0.0000311	0.0000093	0.0000325
343	0.0000757	0.0000277	0.0000078	0.0000318
344	-0.0000109	0.0000456	0.0000116	0.0000375
347	-0.0000213	0.0000261	0.0000075	0.0000224
348	0.0000047	0.0000213	0.0000021	0.0000155
351	0.0000441	0.0000224	0.0000050	0.0000278
352	0.0000133	0.0000226	0.0000049	0.0000272
353	-0.0001571	0.0000284	0.0000087	0.0000235
355	-0.0000029	0.0000871	0.0000141	0.0002294
362	0.0000198	0.0000256	0.0000069	0.0000396
365	-0.0000991	0.0000354	0.0000101	0.0000443
367	0.0000034	0.0000194	0.0000016	0.0000173
369	0.0000200	0.0000253	0.0000068	0.0000345
374	-0.0000131	0.0000229	0.0000061	0.0000205

C.4 The absolute risk aversion coefficients estimated by four different utility functions for north-east region farmers (n=228) (cont.)

Respondent Number	*Absolute risk aversion coefficients*			
	Cubic function	*Negative exponential function*	*Power function*	*Expo-power function*
375	-0.0000114	0.0000552	0.0000131	0.0000318
376	0.0000171	0.0000234	0.0000052	0.0000233
377	-0.0000120	0.0000252	0.0000077	0.0000227
382	0.0000131	0.0000217	0.0000045	0.0000213
385	-0.0000154	0.0000447	0.0000122	0.0000328
387	-0.0000309	0.0000260	0.0000079	0.0000261
390	-0.0000109	0.0000514	0.0000128	0.0000311
391	-0.0000099	0.0000909	0.0000133	0.0000400
392	0.0000092	0.0000428	0.0000135	0.0000599
393	0.0000091	0.0000226	0.0000041	0.0000145
394	0.0000273	0.0000253	0.0000066	0.0000278
395	-0.0001139	0.0000253	0.0000076	0.0000191
396	-0.0000139	0.0000316	0.0000100	0.0000271

Source: Field survey, 2009

C.5 The average of absolute risk aversion coefficients by farmers in the central and north-east regions

Absolute risk aversion coefficients generated from	*Central (n=207)*		*North-east (n=228)*		*Test of difference* [a]
	Mean	*SD*	*Mean*	*SD*	
Cubic function	-0.0000016	0.0001062	-0.0000042	0.0002477	0.14
Negative exponential function	0.0000300	0.0000137	0.0000345	0.0000831	-0.80
Power function	0.0000062	0.0000049	0.0000051	0.0000056	2.07*
Expo-power function	0.0000373	0.0000259	0.0000399	0.0001998	-0.18

[a] Mean of the absolute risk aversion coefficients of the central and north-east respondents are significantly different at $^{*}P < 0.1$, $^{**}P < 0.05$ and $^{***}P < 0.01$.

Source: Field survey, 2009

Appendix D

Correlations of absolute risk aversion coefficients and farmer's socioeconomic characteristics

D.1 Pearson correlation coefficients of the absolute risk aversion coefficients and socioeconomic variables of central region farmers

	$r_a(w)$	*AGE*	*GEN*	*EDU*	*HSIZ*	*FSIZ*	*INCM*
$r_a(w)$	1	0.090	0.001	-0.179***	-0.181***	0.025	0.001
AGE		1	0.047	-0.237***	-0.162***	0.077	0.085
GEN			1	-0.010	-0.046	0.092	0.031
EDU				1	-0.006	-0.095	-0.070
HSIZ					1	-0.016	0.006
FSIZ						1	0.504***
INCM							1

Correlation is significant at * $P < 0.1$, ** $P < 0.05$ and *** $P < 0.01$

D.2 Pearson correlation coefficients of the absolute risk aversion coefficients and socioeconomic variables of north-east region farmers

	$r_a(w)$	*AGE*	*GEN*	*EDU*	*HSIZ*	*FSIZ*	*INCM*
$r_a(w)$	1	-0.198***	0.032	0.135**	0.006	0.008	0.054
AGE		1	-0.069	-0.205***	-0.045	0.095	0.104
GEN			1	0.094	-0.059	0.128**	0.164***
EDU				1	-0.043	0.025	-0.068
HSIZ					1	0.130**	0.172***
FSIZ						1	0.446***
INCM							1

Correlation is significant at * $P < 0.1$, ** $P < 0.05$ and *** $P < 0.01$

Appendix E

Descriptive variables of net farm income calculations

E.1 Descriptive average product prices, yields, plantation areas and production costs for each alternative farming system in the central region rain-fed area at 2008 price levels

Variable	*Unit*	*Alternative farming system*				
		CRFP1	*CRFP2*	*CRFP3*	*CRFP4*	
		Cassava	*Sugarcane*	*Maize*	*Maize*	*Sorghum*
Crop price	baht/kg	1.34	0.72	5.63	6.19	4.53
Yield	kgs/rai	3,261	17,285	755	723	399
Effective area used for each individual crop [a]	rai	21.44	24.93	26.22	21.24	21.67
Variable cost:						
Land preparation cost	baht	11,577.78	22,761.63	12,100.00	12,965.22	
Planting cost	baht	15,413.89	100,483.72	19,518.33	22,186.30	
Harvesting cost	baht	13,202.78	32,670.93	13,561.11	14,688.26	
Total variable costs [a]	baht	40,194.44	155,916.28	45,179.44	49,839.78	
Fixed cost:						
Land tax	baht	99.44	91.26	99.89	67.59	
Rent	baht	-	5,381.39	1,952.78	2,521.74	
Depreciation [b]:						
Four wheel tractor	baht	-	5,881.91	2,277.78	479.35	
Hand tractor	baht	2,063.15	1,989.59	1,087.68	2,048.13	
Irrigation pumps	baht	365.74	229.46	484.26	182.75	
Car or truck	baht	401.11	2,706.67	425.93	755.94	
Other farm assets	baht	1,675.19	1,402.49	1,793.59	2,168.33	
Sub Total	baht	4,505.19	12,210.12	6,069.24	5,634.51	
Total fixed costs [a]	baht	4,604.64	17,677.19	8,121.91	8,223.83	
Total production costs [c]	baht	44,799.08	173,593.47	53,301.35	58,063.61	

[a] Deterministic variables will be incorporated into the stochastic simulation model to evaluate an empirical probability distribution of annual net farm income for each alternative farming system in SERF analysis.
[b] Estimated using the straight line depreciation method.
[c] Total production costs = Total variable cost + Total fixed cost

Source: Field survey, 2009

E.2 Descriptive average product prices, yields, plantation areas and production costs for each alternative farming system in the central region irrigated area at 2008 price levels

Variable	*Unit*	*Alternative farming system*				
		CIFP1		*CIFP2*		
		WSR	*DSR I*	*WSR*	*DSR I*	*DSR II*
Crop price	baht/kg	9.86	9.80	10.02	9.74	9.68
Yield	kgs/rai	799	804	800	784	780
Effective area used for each individual crop [a]	rai	20.45	20.48	21.82	21.82	21.58
Variable cost:						
Land preparation cost	baht	33,394.25		56,144.00		
Planting cost	baht	61,940.70		93,778.00		
Harvesting cost	baht	31,200.12		56,552.00		
Total variable costs [a]	baht	126,535.07		206,474.00		
Fixed cost:						
Land tax	baht	75.14		84.60		
Rent	baht	7,402.79		5,338.00		
Depreciation [b]:						
Four wheel tractor	baht	882.95		494.43		
Hand tractor	baht	1,480.20		2,470.92		
Irrigation pumps	baht	396.13		353.44		
Car or truck	baht	1,582.46		3,285.21		
Other farm assets	baht	2,474.10		3,954.55		
Sub Total	baht	7,283.04		10,560.54		
Total fixed costs [a]	baht	14,527.37		15,983.14		
Total production costs [c]	baht	141,062.44		222,457.14		

[a] Deterministic variables will be incorporated into the stochastic simulation model to evaluate an empirical probability distribution of annual net farm income for each alternative farming system in SERF analysis.
[b] Estimated using the straight line depreciation method.
[c] Total production costs = Total variable cost + Total fixed cost

Source: Field survey, 2009

E.3 Descriptive average product prices, yields, plantation areas and production costs for each alternative farming system in the north-east region rain-fed area at 2008 price levels

Variable	*Unit*	*Alternative farming system*												
		NRFP1	*NRFP2*		*NRFP3*		*NRFP4*		*NRFP5*			*NRFP6*		
		WSR	*WSR*	*Cassava*	*WSR*	*Sugar cane*	*WSR*	*Cattle*	*WSR*	*Cassava*	*Cattle*	*WSR*	*Sugar cane*	*Cattle*
Crop price	baht/kg	8.90	9.60	1.42	8.66	0.83	9.94		7.73	1.29		8.23	0.79	
Animal price	baht/head							5,732			7,060			8,500
Yield	kgs/rai	366	392	2,249	441	8,441	357		377	2,204		345	7,163	
Effective area used for each individual crop [a]	rai	9.09	8.97	9.31	8.52	11.21	15.97		10.20	10.80		9.00	9.57	
Animal sold [a]	head							1.90			1.20			1.42
Variable cost:														
Land preparation cost	baht	2,652.78	6,881.67		11,197.93		4,481.48		5,530.00			7,894.28		
Planting cost	baht	6,560.36	13,411.11		31,948.27		11,558.24		14,279.00			21,982.86		
Harvesting cost	baht	2,742.07	8,290.33		15,844.14		5,713.67		8,396.00			12,910.00		
Feed cost	baht	-	-		-		942.41		608.00			242.86		
Total variable costs [a]	baht	11,955.21	28,583.11		58,990.34		22,695.80		28,813.00			43,030.00		
Fixed cost:														
Land tax	baht	44.85	68.66		82.15		79.99		108.30			94.00		
Rent	baht	17.14	14.81		-		-		-			-		
Depreciation [b]:														
Four wheel tractor	baht	-	500.00		-		296.30		-			-		
Hand tractor	baht	834.65	1,843.36		2,540.86		1,182.07		2,218.33			1,304.45		
Irrigation pumps	baht	81.83	227.78		280.15		121.96		225.00			166.67		
Car or truck	baht	134.76	216.97		658.73		385.67		60.00			-		
Other farm assets	baht	1,275.53	2,461.11		2,507.29		2,521.50		2,426.44			2,554.36		
Sub Total	baht	2,326.78	5,249.23		5,987.04		4,507.49		4,959.78			4,025.48		
Total fixed costs [a]	baht	2,388.77	5,332.71		6,069.19		4,587.49		5,068.08			4,119.48		
Total production costs [c]	baht	14,343.98	33,915.82		65,059.53		27,283.29		33,881.08			47,149.48		

[a] Deterministic variables will be incorporated into the stochastic simulation model to evaluate an empirical probability distribution of annual net farm income for each alternative farming system in SERF analysis.
[b] Estimated using the straight line depreciation method.
[c] Total production costs = Total variable cost + Total fixed cost

E.4 Descriptive average product prices, yields, plantation areas and production costs for each alternative farming system in the north-east region irrigated area at 2008 price levels

Variable	*Unit*	*Alternative farming system*							
		NIFP1		*NIFP2*			*NIFP3*		
		WSR	*DSR I*	*WSR*	*DSR I*	*Tomatoes*	*WSR*	*DSR I*	*Cattle*
Crop price	baht/kg	9.35	8.89	9.58	10.05	12.17	8.09	7.66	
Animal price	baht/head								6,634.29
Yield	kgs/rai	404.07	622.28	423.76	607.78	2,544.44	472.74	613.41	
Effective area used for each individual crop [a]	rai	12.55	12.77	10.33	10.11	0.58	8.88	8.84	
Animal sold [a]	head								1.00
Variable cost:									
Land preparation cost	baht	9,550.52			7,577.78			5,954.29	
Planting cost	baht	24,747.93			29,644.44			20,306.29	
Harvesting cost	baht	13,786.77			12,311.11			10,635.00	
Feed cost	baht	-			-			1,072.00	
Total variable costs [a]	baht	48,085.22			49,533.33			38,010.43	
Fixed cost:									
Land tax	baht	47.62			36.44			42.97	
Rent	baht	67.50			-			114.29	
Depreciation [b]:									
Four wheel tractor	baht	1,619.79			-			333.33	
Hand tractor	baht	1,277.82			1,726.78			1,226.38	
Irrigation pumps	baht	182.30			231.30			179.71	
Car or truck	baht	632.06			333.33			469.76	
Other farm assets	baht	2,703.66			1,850.52			2,188.40	
Sub Total	baht	6,415.63			4,141.93			4,397.59	
Total fixed costs [a]	baht	6,530.75			4,178.37			4,554.84	
Total production costs [c]	baht	54,615.97			53,711.7			42,565.27	

[a] Deterministic variables will be incorporated into the stochastic simulation model to evaluate an empirical probability distribution of annual net farm income for each alternative farming system in SERF analysis.
[b] Estimated using the straight line depreciation method.
[c] Total production costs = Total variable cost + Total fixed cost

Appendix F

Price and yield statistics of the individual crops

F.1 Descriptive price statistics of the individual crops for the alternative farming systems in the central region in baht per kilogram, 1998-2008

Year	*WSR* [a]	*DSR* [a]	*Cassava* [a]	*Sugarcane* [a]	*Maize* [a]	*Sorghum* [a]
			Rain-fed area			
1998	-	-	1.340	0.600	3.850	3.850
1999	-	-	0.770	0.487	4.060	2.640
2000	-	-	0.600	0.477	4.010	3.860
2001	-	-	0.700	0.567	3.930	3.180
2002	-	-	1.010	0.441	3.910	3.200
2003	-	-	0.930	0.508	4.330	3.340
2004	-	-	0.930	0.315	4.400	4.290
2005	-	-	1.540	0.509	4.810	4.040
2006	-	-	1.220	0.712	5.200	5.360
2007	-	-	1.290	0.646	6.560	6.020
2008	-	-	1.790	0.516	6.380	5.770
Mean			1.102	0.525	4.676	4.141
CV [b]			33.48	20.19	20.94	27.07
			Irrigated area			
1998	6.543	7.020	-	-	-	-
1999	5.570	5.203	-	-	-	-
2000	4.724	4.237	-	-	-	-
2001	4.360	3.969	-	-	-	-
2002	4.640	4.462	-	-	-	-
2003	4.702	4.687	-	-	-	-
2004	6.240	5.501	-	-	-	-
2005	6.704	6.741	-	-	-	-
2006	6.909	6.823	-	-	-	-
2007	6.673	6.485	-	-	-	-
2008	9.496	12.133	-	-	-	-
Mean	6.051	6.114				
CV [b]	24.71	37.36				

[a] Averaged from the province-level price data in the study areas.

[b] $CV = \left(\frac{SD}{\bar{X}}\right) \times 100$ where SD = Standard deviation and $\bar{X}$ = Arithmetic mean.

Source: Office of Agricultural Economics (2009)

F.2 Descriptive price statistics of the individual crops and cattle for the alternative farming systems in the north-east region in baht per kilogram and baht per head, 1998-2008

Year	*WSR* [a]	*DSR* [a]	*Cassava* [a]	*Sugarcane* [a]	*Tomatoes* [a]	*Cattle* [b]
			Rain-fed area			
1998	6.516	-	1.447	0.507	-	7,745
1999	6.761	-	0.840	0.466	-	8,785
2000	6.980	-	0.637	0.436	-	10,793
2001	5.732	-	0.860	0.546	-	11,850
2002	5.341	-	1.100	0.463	-	12,776
2003	7.002	-	0.960	0.453	-	14,275
2004	8.557	-	0.947	0.457	-	14,976
2005	7.781	-	1.450	0.518	-	14,418
2006	7.976	-	1.247	0.756	-	14,937
2007	8.652	-	1.410	0.659	-	14,294
2008	12.773	-	1.923	0.686	-	13,206
Mean	7.643		1.165	0.540		12,550
CV [c]	26.22		31.84	20.37		19.90
			Irrigated area			
1998	6.521	6.288	-	-	6.610	7,745
1999	6.919	5.119	-	-	6.580	8,785
2000	7.037	3.978	-	-	7.330	10,793
2001	5.682	3.835	-	-	7.960	11,850
2002	5.349	4.645	-	-	8.090	12,776
2003	7.068	4.244	-	-	7.930	14,275
2004	8.556	5.246	-	-	10.700	14,976
2005	7.773	5.713	-	-	11.450	14,418
2006	8.037	5.834	-	-	10.590	14,937
2007	8.723	6.427	-	-	12.010	14,294
2008	12.423	9.622	-	-	10.520	13,206
Mean	7.644	5.541			9.070	12,550
CV [c]	25.10	29.22			20.66	19.90

[a] Averaged from the province-level price data in the study areas.
[b] Cattle price is the average prices of the medium size live cattle (250-350 kilograms) in the north-east region.
[c] $CV = \left(\frac{SD}{\bar{X}}\right) \times 100$ where SD = Standard deviation and $\bar{X}$ = Arithmetic mean.

Source: Office of Agricultural Economics (2009)

F.3 Descriptive yield statistics of the individual crops for the alternative farming systems in the central region in kilograms per rai, 1998-2008

Year	*WSR* [a]	*DSR* [a]	*Cassava* [a]	*Sugarcane* [a]	*Maize* [a]	*Sorghum* [a]
			Rain-fed area			
1998	-	-	2,670	7,515	596	245
1999	-	-	2,829	8,576	598	273
2000	-	-	2,964	8,968	630	285
2001	-	-	2,874	8,905	654	295
2002	-	-	2,674	9,296	659	302
2003	-	-	2,837	10,485	645	306
2004	-	-	3,602	9,324	609	220
2005	-	-	2,921	7,115	589	313
2006	-	-	3,800	7,266	622	223
2007	-	-	3,906	9,583	626	277
2008	-	-	3,557	10,444	628	261
Mean			3,148.54	8,861.54	623.27	272.73
CV [b]			14.85	13.14	3.77	11.83
			Irrigated area			
1998	543	691	-	-	-	-
1999	569	727	-	-	-	-
2000	554	730	-	-	-	-
2001	602	722	-	-	-	-
2002	722	673	-	-	-	-
2003	651	724	-	-	-	-
2004	665	703	-	-	-	-
2005	680	701	-	-	-	-
2006	663	718	-	-	-	-
2007	664	717	-	-	-	-
2008	666	727	-	-	-	-
Mean	634.36	712.02				
CV [b]	9.17	2.52				

[a] Averaged from the province-level yield data in the study areas.

[b] $CV = \left(\frac{SD}{\bar{X}}\right) \times 100$ where SD = Standard deviation and $\bar{X}$ = Arithmetic mean.

Source: Office of Agricultural Economics (2009)

F.4 Descriptive yield statistics of the individual crops for the alternative farming systems in the north-east region in kilograms per rai, 1998-2008

Year	*WSR* [a]	*DSR* [a]	*Cassava* [a]	*Sugarcane* [a]	*Tomatoes* [a]
		Rain-fed area			
1998	240	-	2,285	7,325	-
1999	300	-	2,416	8,669	-
2000	348	-	2,595	9,885	-
2001	321	-	2,688	9,094	-
2002	335	-	2,630	9,633	-
2003	347	-	2,899	10,608	-
2004	343	-	3,198	9,168	-
2005	354	-	2,691	7,730	-
2006	346	-	3,379	7,800	-
2007	347	-	3,640	10,356	-
2008	337	-	3,252	11,543	-
Mean	328.84		2,879.39	9,255.14	
CV [b]	10.11		14.95	14.24	
		Irrigated area			
1998	224	442	-	-	3,170
1999	316	455	-	-	4,403
2000	355	502	-	-	3,833
2001	331	523	-	-	3,675
2002	387	466	-	-	2,477
2003	380	514	-	-	3,985
2004	376	504	-	-	4,741
2005	393	508	-	-	4,686
2006	371	487	-	-	3,322
2007	382	535	-	-	3,381
2008	361	543	-	-	4,180
Mean	352.09	498.09			3,804.82
CV [b]	13.87	6.52			18.17

[a] Averaged from the province-level yield data in the study areas.

[b] $CV = \left(\frac{SD}{\bar{X}}\right) \times 100$ where SD = Standard deviation and $\bar{X}$ = Arithmetic mean.

Source: Office of Agricultural Economics (2009)

Appendix G

Inflation-adjusted prices of the individual crops

G.1 Consumer price index (CPI) of Thailand, 1998-2008

Year	*Consumer price index*	*Annual change (per cent)*
1998	82.0	8.1
1999	82.2	0.3
2000	83.5	1.6
2001	84.9	1.6
2002	85.4	0.7
2003	87.0	1.8
2004	89.4	2.7
2005	93.4	4.5
2006	97.8	4.7
2007	100.0	2.3
2008	105.4	5.5

Source: Bureau of Trade and Economic Indices (2010)

G.2 Inflation-adjusted prices of the individual crops for the alternative farming systems in the central region in baht per kilogram, in 2008 baht values

Year	*WSR*	*DSR*	*Cassava*	*Sugarcane*	*Maize*	*Sorghum*
			Rain-fed area			
1998	-	-	1.722	0.771	4.949	4.949
1999	-	-	0.987	0.624	5.206	3.385
2000	-	-	0.757	0.602	5.062	4.872
2001	-	-	0.869	0.704	4.879	3.948
2002	-	-	1.247	0.544	4.826	3.949
2003	-	-	1.127	0.615	5.246	4.046
2004	-	-	1.096	0.371	5.187	5.058
2005	-	-	1.738	0.574	5.428	4.559
2006	-	-	1.315	0.767	5.604	5.777
2007	-	-	1.360	0.681	6.914	6.345
2008	-	-	1.790	0.516	6.380	5.770
Mean			1.273	0.616	5.425	4.787
CV [a]			27.86	18.94	12.11	19.20
			Irrigated area			
1998	8.410	9.023	-	-	-	-
1999	7.142	6.672	-	-	-	-
2000	5.963	5.348	-	-	-	-
2001	5.412	4.927	-	-	-	-
2002	5.726	5.507	-	-	-	-
2003	5.696	5.678	-	-	-	-
2004	7.356	6.486	-	-	-	-
2005	7.566	7.607	-	-	-	-
2006	7.446	7.353	-	-	-	-
2007	7.033	6.835	-	-	-	-
2008	9.496	12.133	-	-	-	-
Mean	7.022	7.052				
CV [a]	17.90	29.17				

[a] $CV = \left(\frac{SD}{\bar{X}}\right) \times 100$ where SD = Standard deviation and $\bar{X}$ = Arithmetic mean.

Source: Own calculations

G.3 Inflation-adjusted prices of the individual crops and cattle for the alternative farming systems in the north-east region in baht per kilogram and baht per head, in 2008 baht values

Year	*WSR*	*DSR*	*Cassava*	*Sugarcane*	*Tomatoes*	*Cattle*
			Rain-fed area			
1998	8.375	-	1.859	0.652	-	9,955
1999	8.669	-	1.077	0.598	-	11,264
2000	8.811	-	0.804	0.550	-	13,624
2001	7.116	-	1.068	0.677	-	14,711
2002	6.592	-	1.358	0.571	-	15,768
2003	8.483	-	1.163	0.549	-	17,294
2004	10.088	-	1.116	0.538	-	17,656
2005	8.780	-	1.636	0.585	-	16,270
2006	8.596	-	1.344	0.814	-	16,098
2007	9.119	-	1.486	0.695	-	15,066
2008	12.773	-	1.923	0.686	-	13,206
Mean	8.855		1.349	0.628		14,628
CV [a]	18.06		26.02	13.50		16.58
			Irrigated area			
1998	8.381	8.082	-	-	8.496	9,955
1999	8.872	6.564	-	-	8.437	11,264
2000	8.883	5.021	-	-	9.252	13,624
2001	7.054	4.761	-	-	9.882	14,711
2002	6.601	5.733	-	-	9.985	15,768
2003	8.562	5.142	-	-	9.607	17,294
2004	10.087	6.185	-	-	12.615	17,656
2005	8.772	6.447	-	-	12.921	16,270
2006	8.661	6.287	-	-	11.413	16,098
2007	9.194	6.774	-	-	12.659	15,066
2008	12.423	9.622	-	-	10.520	13,206
Mean	8.863	6.420			10.526	14,628
CV [a]	17.13	22.06			15.64	16.58

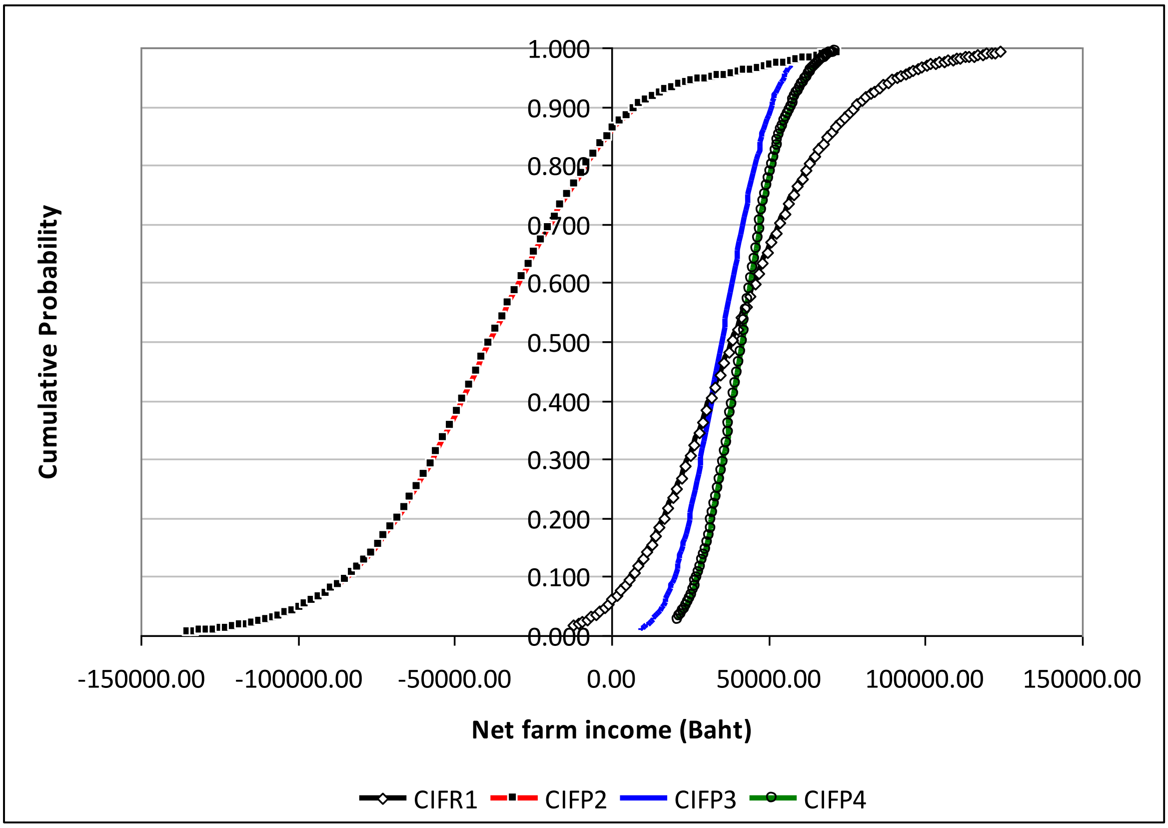
[a] $CV = \left(\frac{SD}{\bar{X}}\right) \times 100$ where SD = Standard deviation and $\bar{X}$ = Arithmetic mean.

Source: Own calculations

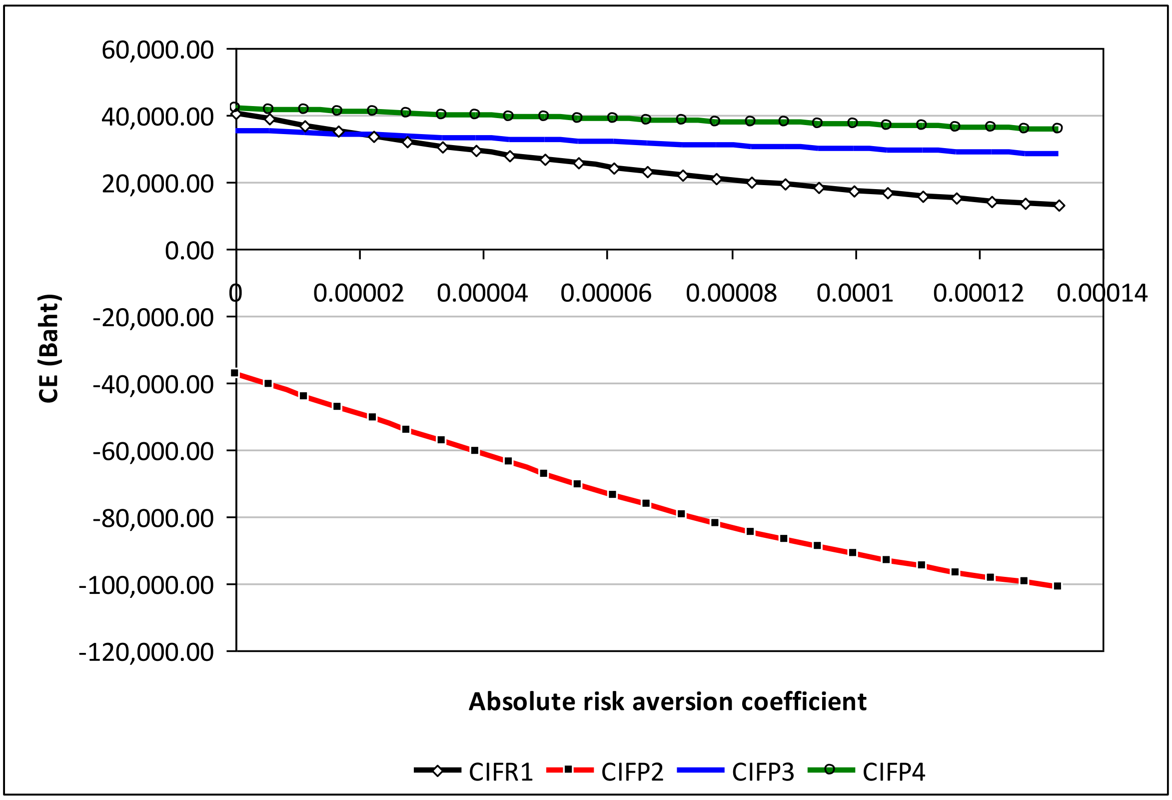
Appendix H

Sensitivity analysis SERF results

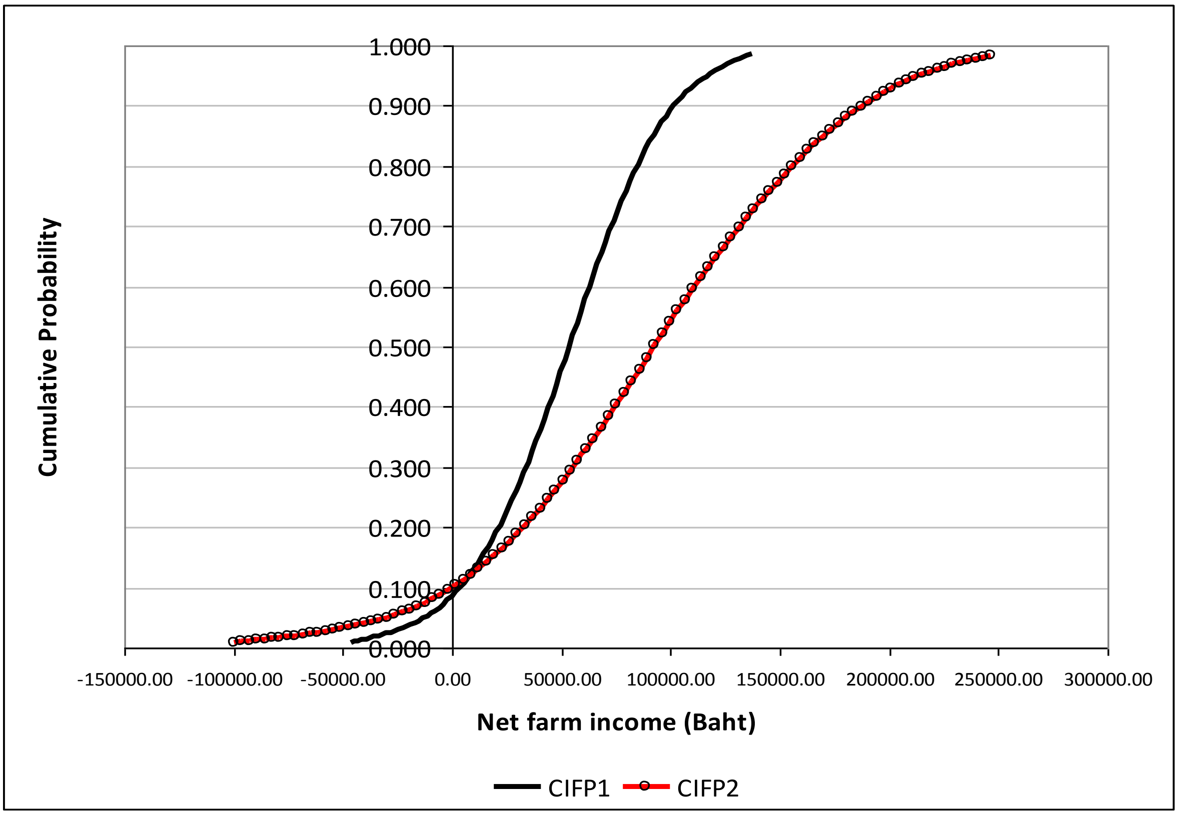
H.1 Simulated CDFs of annual net farm income for the CRFP1-4 in the central region rain-fed area using inflation-adjusted commodity prices



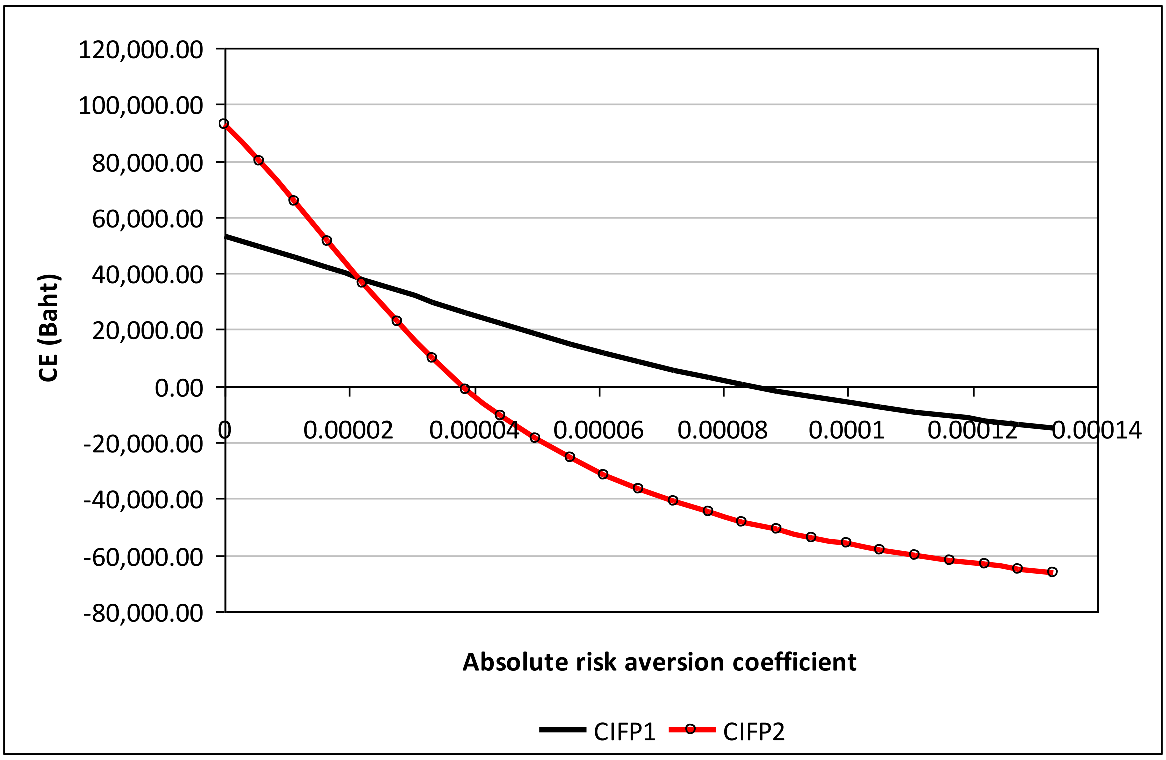
H.2 CEs of the CRFP1-4 in the central region rain-fed area with different magnitudes of the absolute risk aversion coefficient under the negative exponential utility function



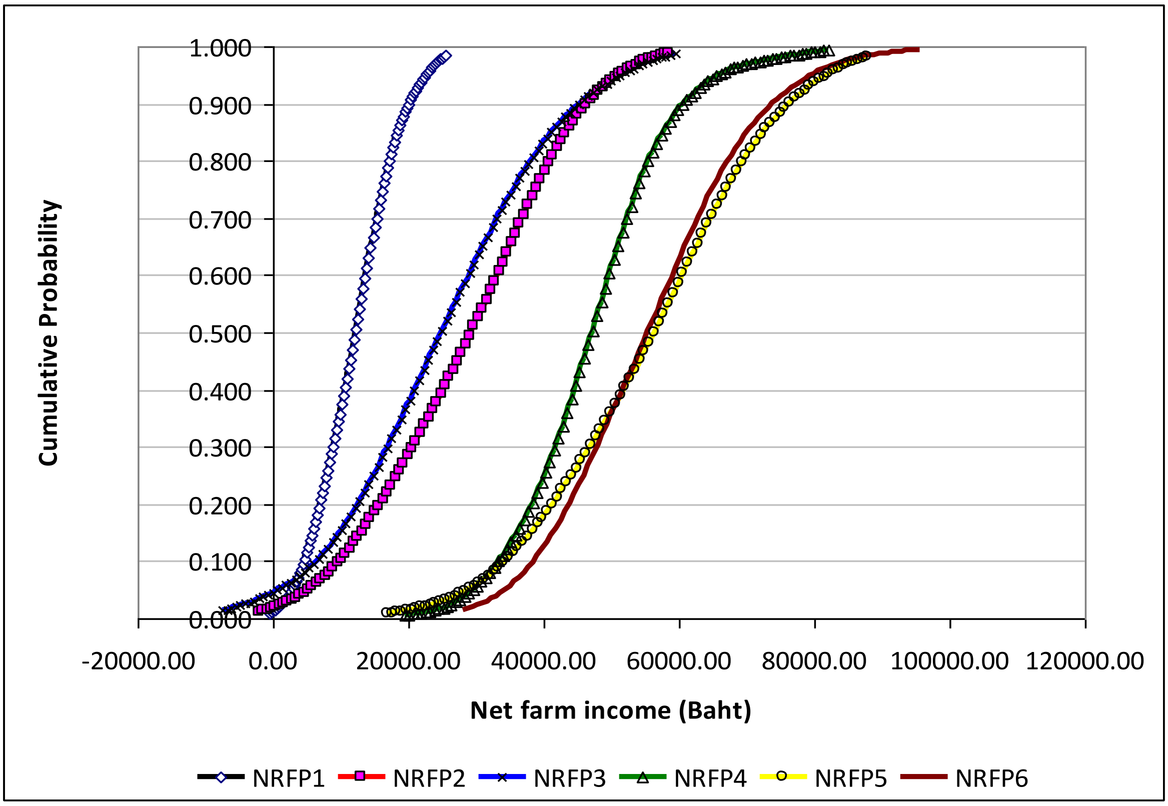
H.3 Simulated CDFs of annual net farm income for the CIFP1 and 2 in the central region irrigated area using inflation-adjusted commodity prices



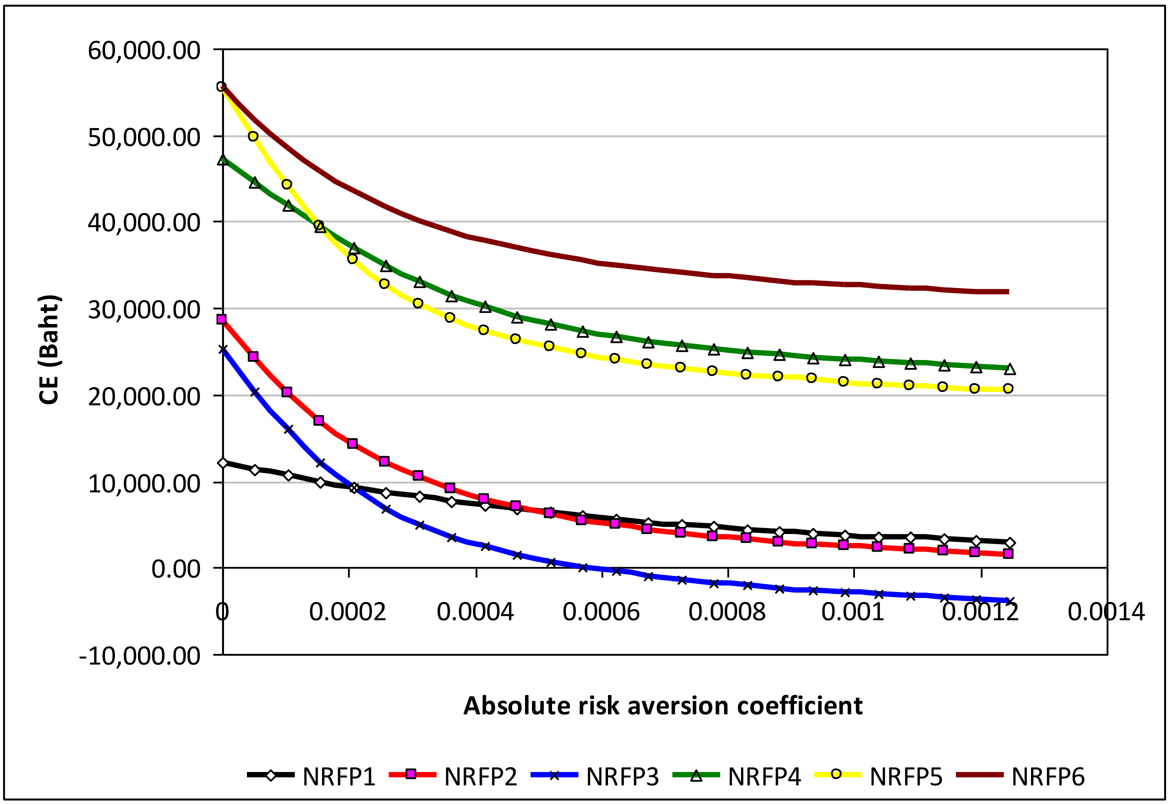
H.4 CEs of the CRFP1 and 2 in the central region irrigated area with different magnitudes of absolute the risk aversion coefficient under the negative exponential utility function



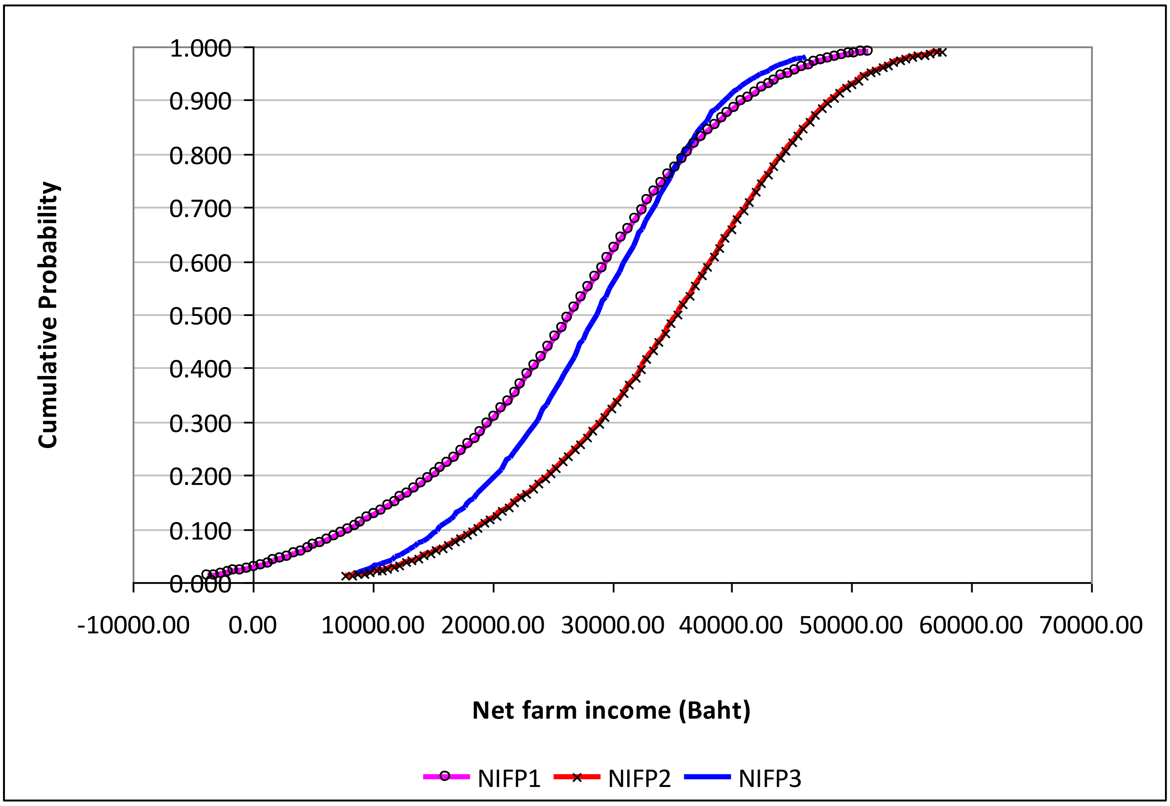
H.5 Simulated CDFs of annual net farm income for the NRFP1-6 in the north-east region rain-fed area using inflation-adjusted commodity prices



H.6 CEs of the NRFP1-6 in the north-east region rain-fed area with different magnitudes of the absolute risk aversion coefficient under the negative exponential utility function



H.7 Simulated CDFs of annual net farm income for the NIFP1-3 in the north-east region irrigated area using inflation-adjusted commodity prices



H.8 CEs of the NIFP1-3 in the north-east region irrigated area with different magnitudes of the absolute risk aversion coefficient under the negative exponential utility function